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Cassier's Magazine

Established 1891
Continued as "Cassier's Engineering Monthly"

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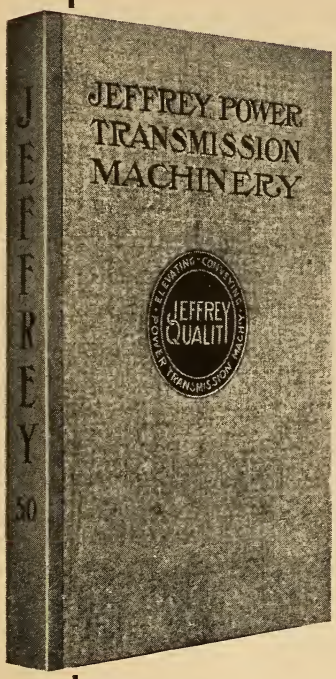

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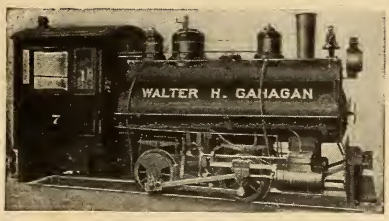

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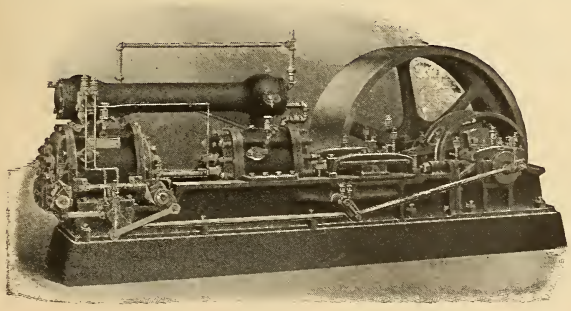

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One of the excellent articles is on "The Delaware and Hudson Shops," written by O. D. Lee. The departments of New Inventions of Mechanical Sort, on Letters and News Notes, are well handled. In view of the debate over big ships a brief article on the new German "Imperator" is of interest, for it is to be some 4,000 higher tonnage than the Olympic, which is now the greatest steamship in the world, while it is to be 12 feet longer and four wider, capable of carrying, crew and all, a total of over 5,000 persons on a single trip.

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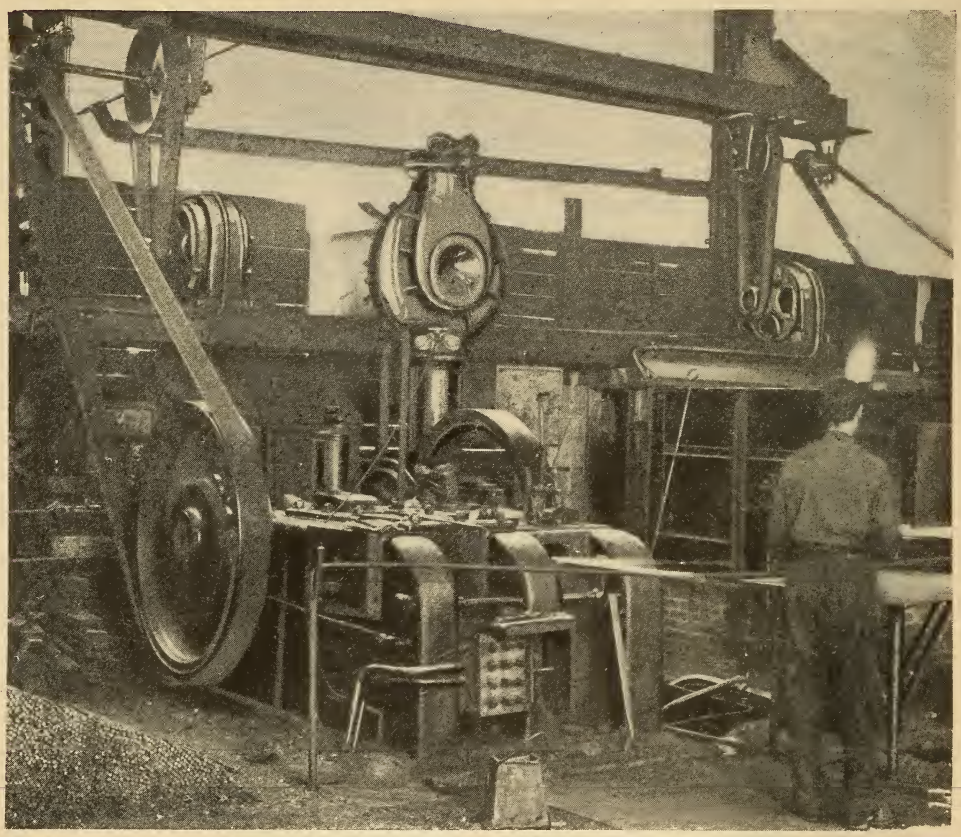

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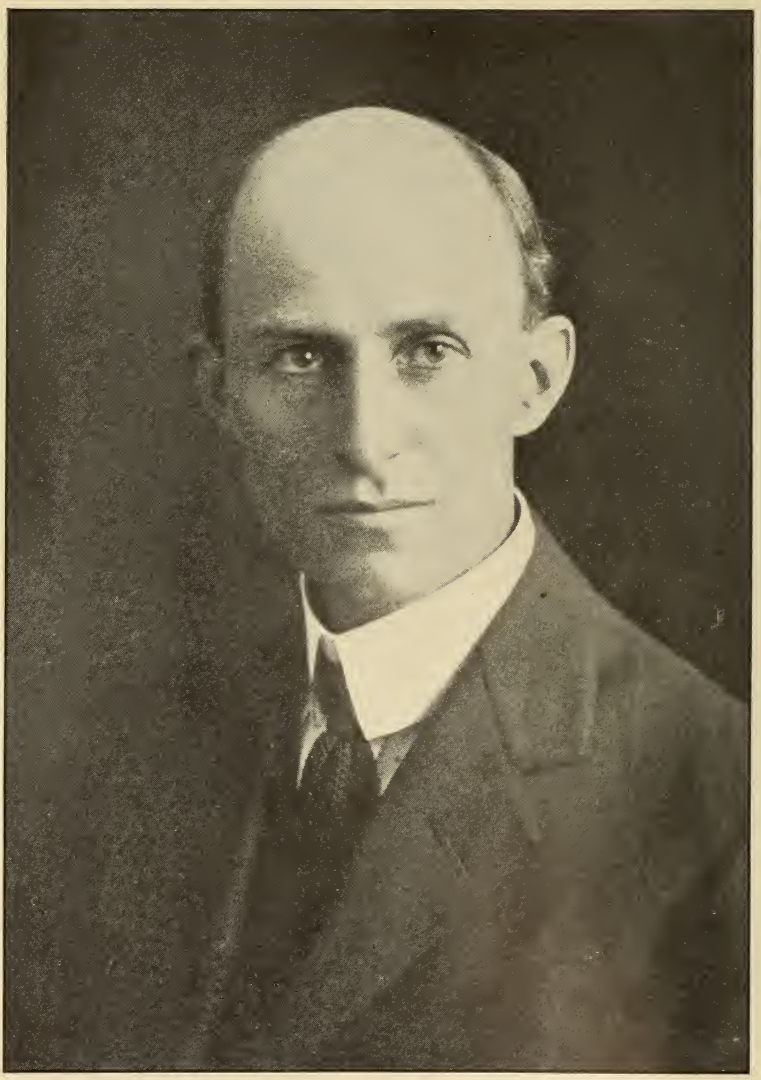
The death of Wilbur Wright, at the early age of forty-five years, lends a sad interest to the portrait which we publish in this issue, especially as it seems probable that he was about to add materially to practical knowledge in soaring flight, had his life been spared.

Whatever position may be given to his life-work, as time may enable it to be estimated, there appears to be no doubt that, in connection with his brother Orville, he was the first to demonstrate the practical possibility of mechanical flight. This result followed, not upon the production of any startling novelty in mechanical construction, nor after the discovery of any new law of physics, but as the consequence of patient and careful experimental work, at first with gliders, then with motors, and finally with the combination of both.

Beginning a careful series of experiments with gliding machines as long ago as 1896, it was not until 1903 that the first successful motor-driven flights were made, and even these were kept private until six years ago. By 1908 the brothers were ready for such demonstrations as were required to overcome public incredulity, and to-day the fact that it was the Wrights who taught the world how to fly is generally accepted.

One of the grateful things for which the memory of Wilbur Wright will always be held secure lies in his willingness to give full credit to the work of those who preceded him, and the names of Lilienthal, Chanute, and especially Langley, were honored by him as pioneers who helped to clear the way for his work. His own place in the hall of fame is secure, and whatever may yet be accomplished in the domain of the air, it will always be freely granted that Wilbur Wright showed mankind how to fly.



WILBUR WRIGHT

See Reverse Side

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XLII JULY, 1912 No. 1

THE MECHANICAL DISPOSAL OF ASHES FROM STEAMERS

By J. F. Zimmer, A. M. Inst. C. E.

AUG 1912

THE tendency to utilize mechanical means for handling material has become more and more general, and important new fields for their operation have, within recent years, been opened up in the mechanical disposal of ashes and clinkers from the stokeholes of steamers.

DEVELOPMENT OF ASH EJECTION

In the days of marine engines of small horse-power, and consequent small coal consumption, the refuse of the stokehole was easily dealt with by hand labour, being brought up in buckets and emptied over the side. When the coal consumption had somewhat advanced the same method was used, or simple ash hoists were introduced, still utilizing the bucket, and the general procedure remaining much the same, except that mechanical means were employed to raise the buckets to the deck level or a few yards above it. The ashes or clinkers,—in other words, the refuse from the boilers of large steamers—accumulate so fast that they have to be removed about every four hours from the furnace. After cooling with water, they are generally filled into large iron tubs, which have wheels for their easier movements, and which sometimes run on rails to a suitable position, whence they can be removed on deck and thence overboard at intervals.

The older methods employed ordinary hoists, by means of which the tubs were either raised through a special duct or a shaft, or more often one of the ventilating shafts was used for their passage. On the deck corresponding rails were provided, upon which the tubs were lowered and pushed to the side of the ship and emptied into hopper shoots leading overboard.

THE ASH HOIST

There are a number of improvements on this primitive way, which all consist of a separate vertical pipe or one of the larger ventilating shafts, not less than 24 inches in diameter, fitted with a door above deck, through which the tubs can be removed.

The winch for manipulating the ash hoist is situated either on deck or in the stokehole, and can be manipulated by hand or motor. The tubs are made to open more or less automatically at the highest point into a permanent or movable shoot

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leading overboard, this depending on the position of the hoist, whether near the side or nearer amidship.

Fig. 1 illustrates one of these hoists with automatic discharge, the invention of Mitzlaff. *B* is a ventilating shaft which is used in this case, *C* is the discharge pipe, which leads straight overboard. The ash tub *a* has a conical bottom and cylindrical sides; these are, however, not riveted together, but the sides rest loosely upon the flange of the cone. The chain *b* lifts the cone by a rod fixed to its apex, and passes through a guide in the top of the cylindrical sides, while the latter are attached to the chain *f*. When the tub is raised both chains are wound onto their drums at the same speed and the tub remains intact. As soon, however, as the tub has reached the unloading point, the chain *f* mounts a thicker portion of its drum, and, therefore, travels faster and lifts the sides of the tub off its seat into the position a^1, so that the tub empties itself into the shoot *C*. There is a valve which opens and lets the tub through when rising, in position c^1, and which closes again, in position c^2, after the tub has passed, so as to prevent the ashes falling back down the shoot. There is a rather complicated system of levers manipulated by the sheave of the chain *b*, which moves the valve into position c^1 again,, so as to let the tub pass on its return journey. As soon as the winch is reversed the chain *f* lowers the sides again onto the cone at the bottom and the tub descends intact.

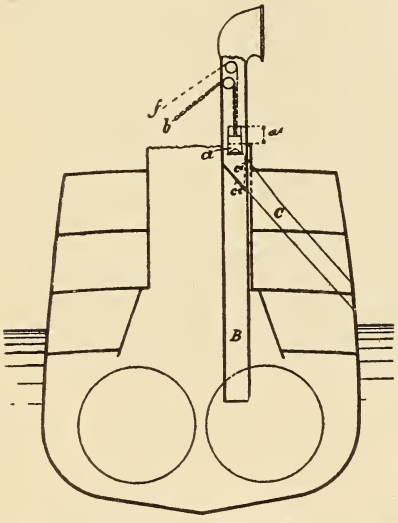


FIG. 1.—ILLUSTRATION OF MITZLAFF HOIST, WITH AUTOMATIC DISCHARGE

A similar plan is that of Adamson & Lee, shown in Fig. 2. The tub of this *G* is supported below its centre of gravity by trunnions resting in the forks of the support *R*. The side of the pipe *W* and its extension prevent the tub from tilting over, the winch *D* lifts the support *R*, with its tub *G*, to just above the discharge shoot *A*, where the guide *E* assists in tipping the tub and emptying the contents down shoot *A* overboard.

The scheme of J. J. and Th. L. Galway is similar; the upper or discharging position is shown in Fig. 3. In the upper end of the shaft is fixed the guide *M*, which tips the tub *J*. The tub is fitted with two pairs of wheels or rollers—J^4, of normal width, and J^3, the upper pair, of double width. The carrying frame *L* of the tub forms a bearing for J^2, the spindle of the lower pair of rollers. When the tub has reached the position shown in the illustration the upper pair of rollers enter the guide *M* and tip the top of the tub forward, whilst the lower pair of rollers proceed in their straight course into the extension J^5, so that the contents of the tub are discharged down the shoot.

A different plan is that of Barreto. It is shown in Fig. 4, and consists of an ordinary bucket elevator which conveys the ashes into the shoot *h*; *e* and e^1 are the termini of the elevator, *f* the chain, and *g* the buckets; *a* is the tank and elevator well combined; it is filled with water and fitted with a grating a^1 to retain pieces of clinker too large for the elevator buckets. Sea-water is let into the tank by pipe *d* and automatic cut-off *c*; the delivery shoot for the ashes is fitted with a valve h^1, which

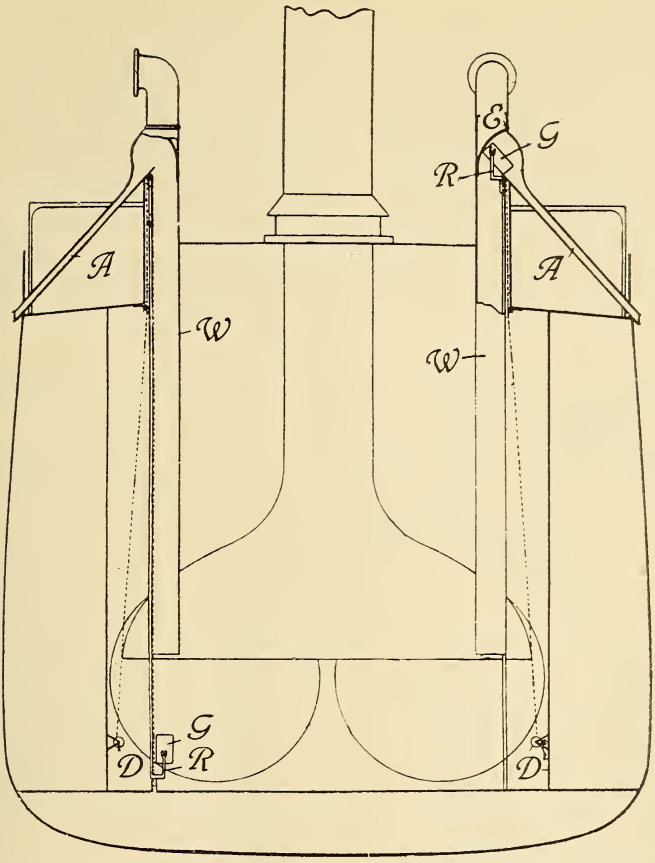


FIG. 2.—DIAGRAMMATICAL VIEW OF ADAMSON & LEE ASH HOIST USED ON DECKS OR IN STOKEHOLES OF VESSELS

opens outward, and with an inspection hole h^2.

All the ash hoists have certain drawbacks or restrictions; they cause the intolerable nuisance of ashes being blown all over the deck of the vessel, to the annoyance and discomfort of passengers and crew. This is especially the case with passenger vessels in hot climates, owing to the ashes being blown into the cabins through the open portholes; if their operation is restricted to night time the noise produced by them is almost equally objectionable. Ash hoists are also restricted to steamers working without forced draught, on account of the communication which the pipe affords between the stokehole and the open; worst of all, they are too slow and altogether inadequate for large steamers. With modern equipments of more powerful engines, and, consequently, much larger coal consumption, the disposal of ashes called for a more effective method; this led to the introduction of the hydro-ejector, which, as the name implies, ejects the ashes by hydraulic force, or, rather, by jets of water under pressure, outside the ship's side, above the waterline. This system answers very well, and is largely used in merchant steamers, in spite of sundry drawbacks; but in the case of battleships it was soon decided that the piercing of the armour to provide outlets for the ash tubes was undesirable on account of weakening the armour.

HYDRO-EJECTORS

Hydro-ejectors were first introduced by Horace See, of New York, and his system is shown by Fig. 5. On the floor of the stokehole is fixed a hopper *A* fitted with a watertight lid *B* and fastenings *g h*. The hopper *A* is joined to the ejector pipe *C*, at the bottom of which is a hydraulic nozzle *F*, regulated by cock *E* and fed by the pressure main *D*. Pipe *C* is bent at its upper end and delivers its load overboard above the waterline; it is also fitted with an air valve *I*, through which air may be admitted during the conveying action, and a cock *c* for emptying the water out of the apparatus after use.

The ejector works as follows: After the cocks and valves *c*, *E* and *I* have been closed, the lid *B* is opened and the hopper *A* filled with ashes; the pressure pump is now started. As soon as the gauge indicates the required pressure the cock *E* is opened quickly and the water under pressure enters through jet *F* at a high speed and forces the ashes through pipe *C* overboard. At the same time, tap *I* is opened to admit air, which acts like an injector in dispersing the ashes. If the coal has a tendency to cake and the ashes contain large pieces of clinker, a grating is placed on top of the hopper and the large pieces are broken with a hammer, so as to prevent the choking of the pipe *C*. But this has the drawback that, unless the pressure gauge is carefully watched and the cock opened at the exact moment, the pipe *D* or the pump might be injured; so the same inventor has added an automatic device to prevent this, which is shown in Fig. 6. In this scheme the exit of the jet *D* is closed by the rod 7, which carries pistons K^1, K^2, of different diameters, and the spring *M* also holds this rod in position. A branch pipe *N* from the hydraulic main leads behind the piston K^1, and likewise by pipes N^1 and N^2, in front

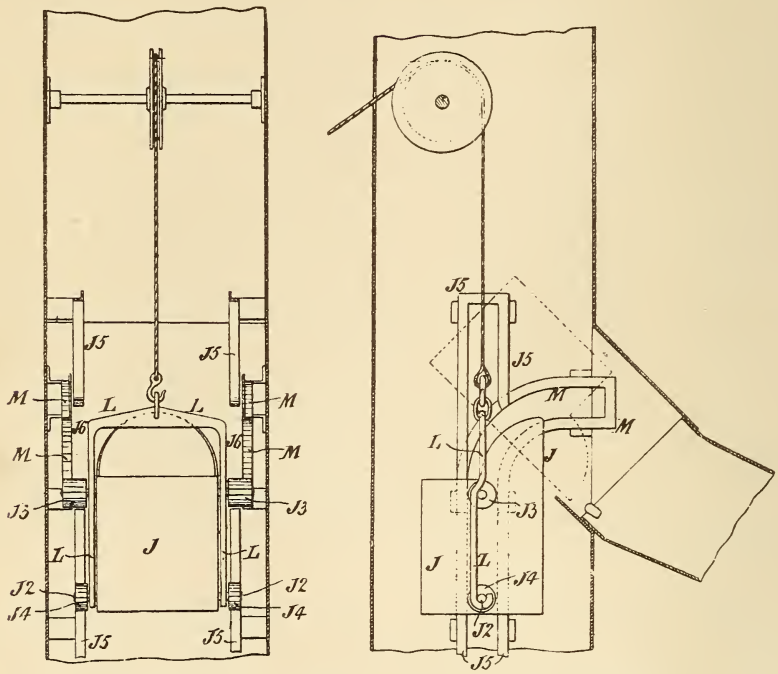


FIG 3.—WORKING PLAN OF THE GALWAY ASH HOIST IN THE UPPER POSITION

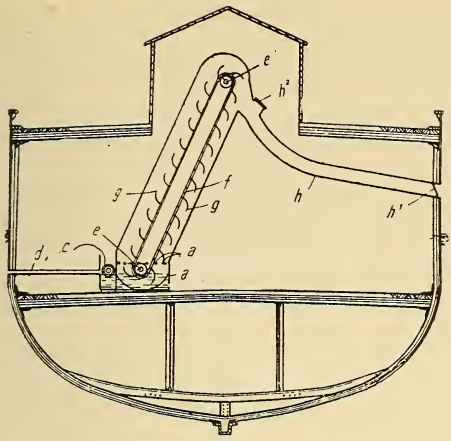


FIG. 4.—DIAGRAM OF BARRETO ASH HOIST, SHOWING THE BUCKET ELEVATOR THAT CONVEYS THE ASHES INTO THE SHOOT

of the piston K^2. The pipes N^1 and N^2 are intercepted by a valve *1*, with its body *3*, in which is fixed spring *2*, which holds the valve with a certain pressure against its seat. In the pipe N^2 is a three-way valve *o* manipulated by an external lever. The action is then as follows:

The pressure from the hydraulic main enters pipe N and forces piston K^1, with its extension, against the seat, keeping the jet D closed; the pressure likewise passes through pipe N^1, and, if sufficient, compresses spring *2* and opens the valve *1*, when the pressure extends also into the pipe N^2 and against the front of piston K^2, which is forced back and jet

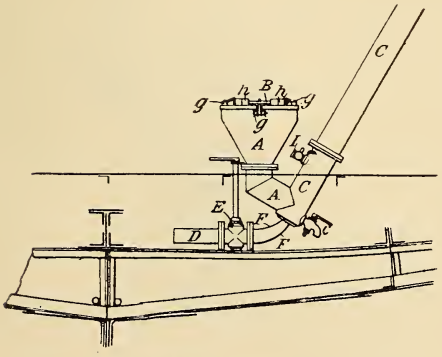


FIG. 5.—ARRANGEMENT OF SEE HYDRAULIC ASH EJECTOR

D opened, when the ash expulsion begins. As soon as the ashes have been disposed of the three-way valve *o* is connected with outlet S when jet D is closed by piston K^1 and spring M. Valve *5* admits air.

Generally, one ejector is used in connection with each stokehole; but the same appliance can also be duplicated to serve two stokeholes, as shown in Fig. 7. *f f* are the two lids of the hoppers A A, and are so connected by a chain h that only one can

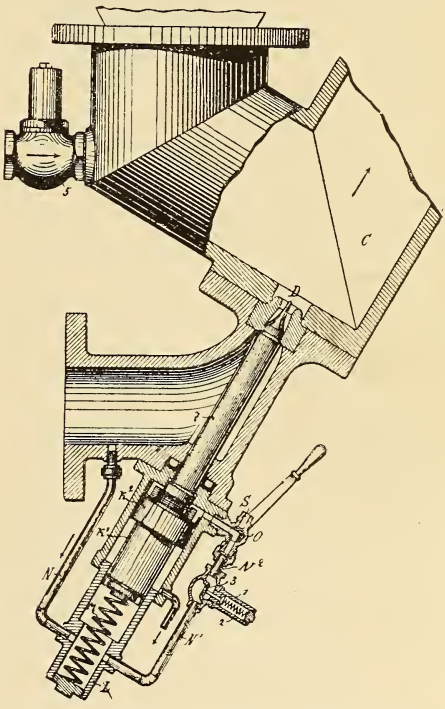


FIG. 6.—SAFETY DEVICE FOR SEE HYDRAULIC ASH EJECTOR

be opened at a time. This construction has, however, several obvious drawbacks.

As there is always a tendency for the finer ashes to accumulate in the bottom of the hopper, where they are out of reach of the water jet, Thorne has constructed a hopper as shown in Fig. 8. This permits a portion of the water from the hydraulic main h to pass through a narrow channel g into the hopper, and thus keeps it

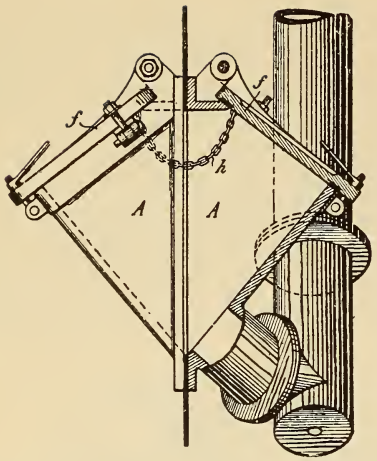


FIG. 7.—ARRANGEMENT OF SEE ASH EJECTOR TO SERVE TWO STOKEHOLES

clean. The amount of water so used can be adjusted by the valve *i*.

Another method is that of Hochstein, shown in Figs. 9 and 10. It is for a similar purpose to See's attachment, Fig. 6; both have the object of preventing shocks in the hydraulic mains at the setting to work of the apparatus and preventing unsatisfactory starting owing to insufficient initial pressure. This is achieved, particularly by Hochstein, by allowing the pump to be always at work, and his apparatus permits, by the movement of a lever, to utilize the water either for the ejector or to return it into the sea. The simplest form is the application of a three-way valve *w*, shown in Fig. 9, which explains itself; it shows the hydraulic main leading into the valve *w*, which conducts the water either into the ejector or right away. In Fig. 10 the hydraulic main enters at *e*, and the water can enter either through jet *b* to the ejector or through jet *c* to some other exit; the jets *b* and *c* are respectively opened or closed by the valves *K* and *i*, which latter form part of a hollow spindle with the openings or ports *d*, *f* and *g*. Attached to this spindle are the pistons *r* and *s*, of different diameters. When the three-way valve *a* is opened, as shown in the drawing, the pipe *p* forms a communication between the hydraulic supply and the larger of the two pistons, and thereby opens jet *b* and starts the ejector with full pressure. When valve *a* is closed, the water enters the ports *d*, in the hollow spindle, and passes through ports *g*, below the smaller piston, and forces the valves into the position shown—that is, the ejector valve *b* is closed and the water escapes through the ports *f* and exit *c*. It will thus be seen that by opening or closing valve *a* the ejector is started or stopped immediately. As it is most essential, for obvious reasons, that the discharge of the ashes should take place at will, either at the port or starboard side of the steamer, ejector installations have either to be provided in duplicate, with the exit on different sides, or if one installation only is to be used, it must be provided with alternate exits, one to port and one to starboard. A scheme providing for this, and also the invention of Hochstein, is shown in Fig. 11, where *a* represents the ash hopper, *b* the ejector pipe and *c c* the two outlets. The valve attachment c^1 by a simple movement conducts the ashes to either side. The two smaller illus-

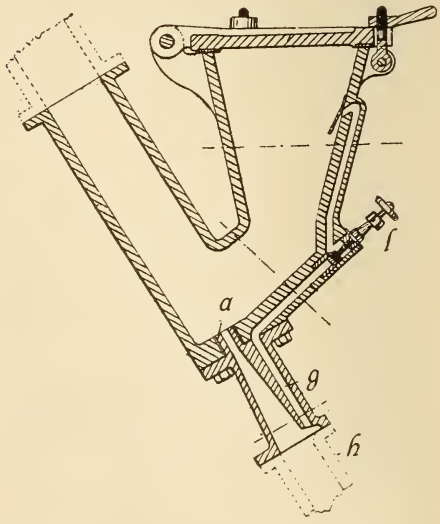


FIG. 8.—OUTLINE OF THE THORNE HOPPER

trations show two sections through the principal parts with the movable distributor *d* and the bend b^1 of the ejector pipe.

The hydraulic ejector by Körting, of injector fame, is represented in Fig. 12, and shows distinct advances in the right direction. The ejector

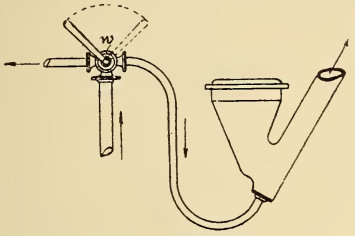


FIG. 9.—THE HOCHSTEIN THREE-WAY VALVE

pipe *b* leads by a bend into the larger pipe *c*, which terminates at the ship's bottom, with an alternative side outlet under water at the side, as shown in dotted lines; *d* is a perforated plate to prevent dust, while *e* is an air inlet, which ensures that the water level is the same in the pipe *c* as outside. The following data are available in connection with this ejector: The water used was of a pressure of 180 pounds per square inch, and

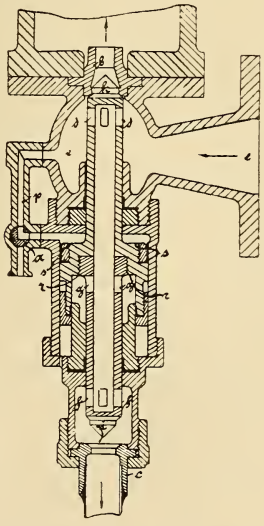


FIG. 10.—HOCHSTEIN METHOD OF PREVENTING SHOCKS IN THE HYDRAULIC MAINS

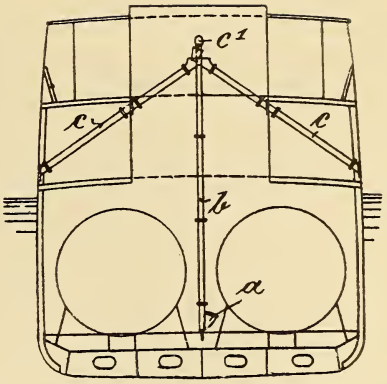


FIG. 11.—PLAN TO DISCHARGE ASHES AT THE PORT AND STARBOARD SIDES OF VESSELS. THE HOCHSTEIN METHOD

passed to the ejector through a 2½-inch pipe. The ejector used 3,300 gallons of water to eject 7 to 8 tons of ashes to a height of 13 to 14 feet through a 4-inch pipe.

EJECTOR PIPES

The bends in the ejector pipes, which are practically indispensable in

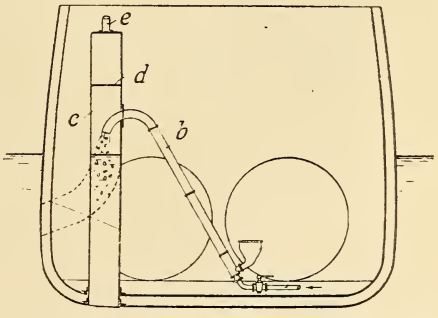


FIG. 12.—ARRANGEMENT OF KORTING HYDRAULIC ASH EJECTOR

all the foregoing installations, have been found to be subject to enormous wear and tear, as, owing to the centrifugal force, all the abrasion takes place on the one side and under the most adverse circumstances. The pipes have, therefore, been made with thicker metal on the side most affected, and also with renewable liners, as well as lined with glass, which is harder than ashes, and so reduces the wear.

There can be no doubt that, where possible, the ideal exit for the discharge of the ashes is vertically down through the ship's bottom, as this method has the following distinct advantages: The discharge pipe is short and straight, without bends; it makes the passage of pipes through the bunkers and decks unnecessary; the condition of the weather is immaterial to the successful expulsion of the ashes, contrary to side delivery above the waterline, as such installations have frequently to be fitted in duplicate on the port and on the starboard side, as already mentioned, so as to enable the discharge of ashes to leeward in all weathers, and even then the head or following wind will cause the seas to carry the ashes back onto the deck, as well as into the stern tubes and sea suctions, and the ashes will cause scoring of the skin plating at and below the waterline. The avoidance of bends in the ash pipes is also of great importance, as we have already seen.

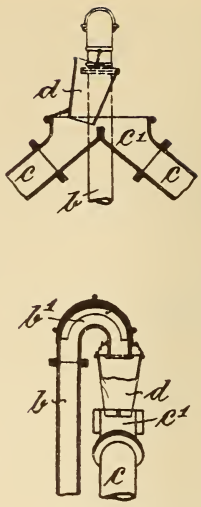


FIG. 14.—DETAIL VIEW OF PNEUMATIC UNDERLINE ASH AND CLINKER EXPELLER, DISCHARGING DOWNWARDS. J. STONE & CO., LTD., DEPTFORD

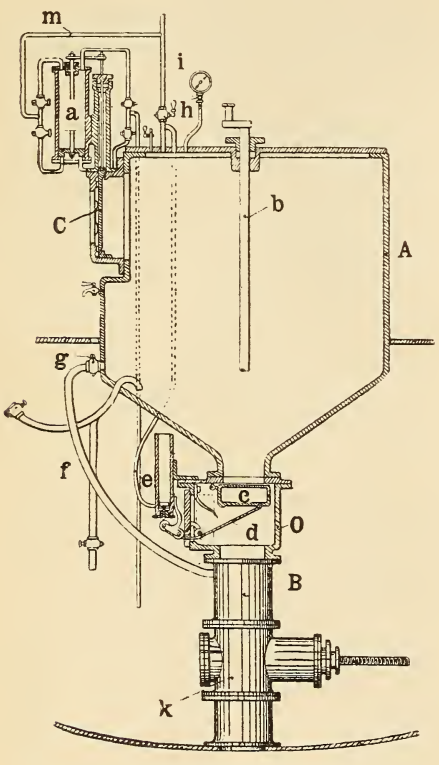


FIG. 13.—ASH EJECTOR FOR COMPRESSED AIR. BROUQUIERE & BAZE

LATEST DEVELOPMENTS

With the advent of the recent types of battleships and cruisers with their powerful turbine engines, the question of the mechanical disposal of the now enormous quantities of ashes has become a most important one. The non-interference with the existing structural arrangements was a *sine qua non*. The Admiralty, while seeking a solution of the difficulty, experimented with an ejector used in the French navy, with a discharge through the bottom of the ship, but it did not answer the requirements of the British navy; the naval authorities, therefore, experimented in the same direction, and eventually produced a system by which the clinkers, ashes and other refuse were first crushed and then expelled by pneumatic pressure through an opening in the bottom of the ship.

Before describing the system adopted by the British navy, let us investigate the French system just mentioned.

The ash ejector for compressed air of Brouquière & Baze is shown in

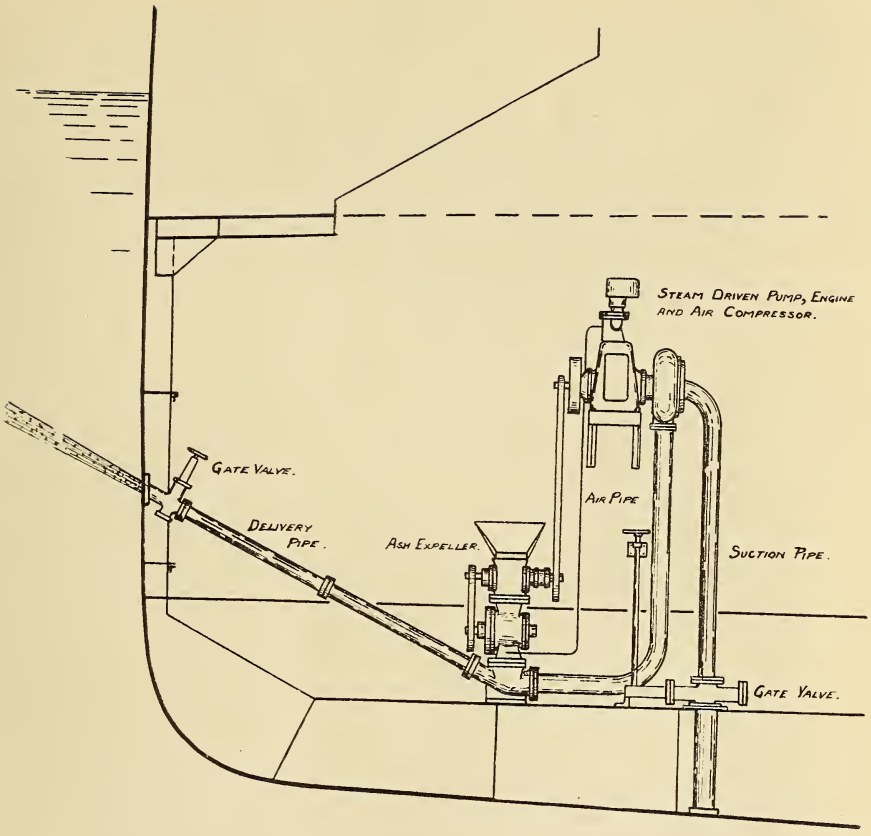


FIG. 15.—DIAGRAM OF THE STONE PATENT HYDRO-PNEUMATIC UNDERLINE ASH EXPELLER USED FOR NAVAL PURPOSES

Fig. 13. The ashes are deposited in the apparatus through the opening *C*, which closes watertight; this door *C* is manipulated by the piston and rod of the pneumatic cylinder *a;* the pipes *m* and *i* bring the supply from the main. The ashes deposited in the hopper *A* are agitated with water by a stirring device manipulated by spindle *b*. The exit of the hopper *A* is closed by a floating valve *c*, which may be opened by the rope *d* connected to a piston in the pneumatic cylinder *e*. Water can be admitted into the hopper *A* from the body *O*, which is normally full of sea-water, through the tap *g*, whilst the compressed air is admitted by cock *h*. The delivery pipe *B* for the ashes may be closed by gate-valve *k*.

The apparatus acts as follows: Compressed air is admitted below the piston in cylinder *a*, whereby the door *c* is opened; after the filling of the hopper, door *C* is again closed by admitting air above the piston of cylinder *a*. The gate valve *k* is now opened to admit sea-water, whereby valve *C* is automatically closed and tap *g* is opened to let water in by pipe *f*, so that the hopper is filled, when the stirrer is set to work. Compressed air is now admitted beneath the piston of cylinder *e*, which, by means of the rope, opens the floating valve *c* into the position shown dotted, to give a free exit to the mixture of

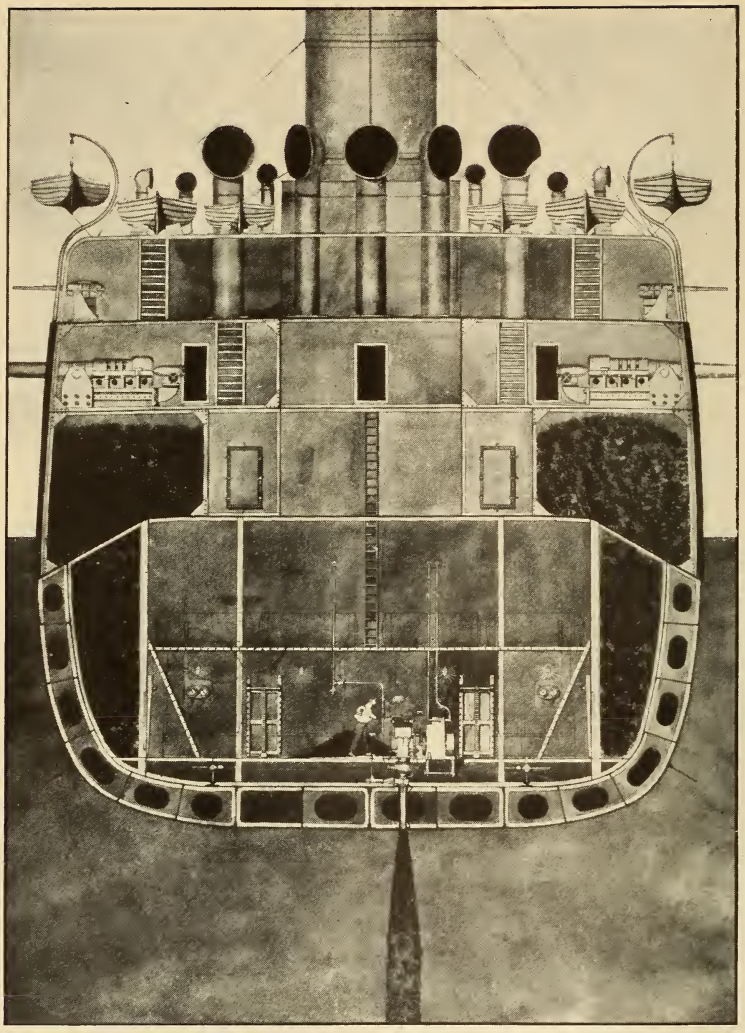


FIG. 16.—STONE UNDERLINE ASH EXPELLER, DISCHARGING THROUGH BOTTOM OF SHIP

ashes and water. Compressed air is at the same time admitted by cock *h*, which forces the ashes out.

The system on which the ashes are disposed of in the British navy consists of two types, and are built by J. Stone & Co., Ltd., of Deptford, which two systems are described as follows: The pneumatic underline ash and clinker expeller, used largely in his Majesty's navy, and the hydro-pneumatic underline ash expeller specially designed for the first class turbine battleships and cruisers. The former type discharges vertically downwards, and such an installation is illustrated in Fig. 14, while the second discharges generally through the side of the vessel beneath the water-line, as shown in Fig. 15. It was necessary to have a side discharge in this case, owing to the fact that the main condenser suctions in the latest turbine battleships are situated in the bottom of the ships, so that an ash discharge vertically downwards would make it possible for some of the

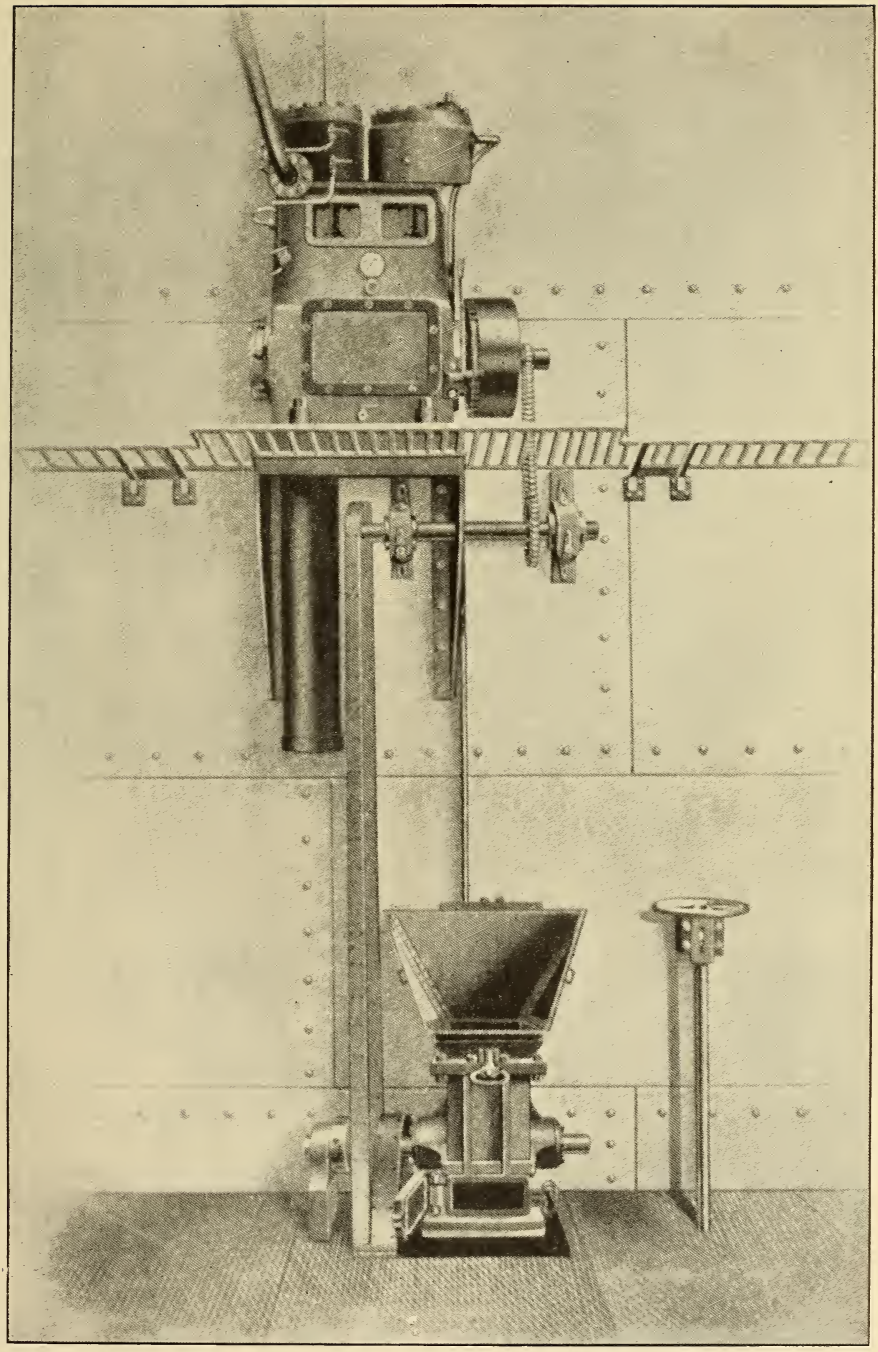


FIG. 17.—APPARATUS OF THE STONE UNDERLINE ASH AND CLINKER EXPELLER AS FITTED IN THE BRITISH NAVY

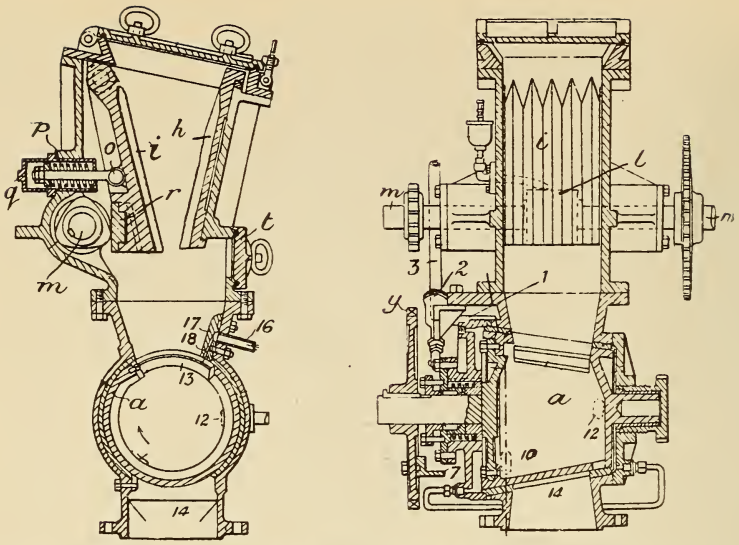


FIG. 18.—ARRANGEMENT OF CRUSHER FOR BREAKING CLINKER FOR DISCHARGE THROUGH STONE EXPELLER

ashes to be taken into the suctions, with disastrous results.

Stone's underline pneumatic ash and clinker expeller, of which the general illustrations in Figs. 14 and 17 give a good idea, consists of a hopper into which the ashes, etc., are shoveled as they come from the furnace; from the hopper the material falls into a pair of crushing jaws, which reduce it to a convenient size for effectual discharge. The ashes so reduced are now admitted intermittently into a revolving drum, which at one period of its revolution receives a charge whilst at another period allows this charge to escape into the sea, whilst at no time allows a communication between the sea and the ship's compartment. Finally, a

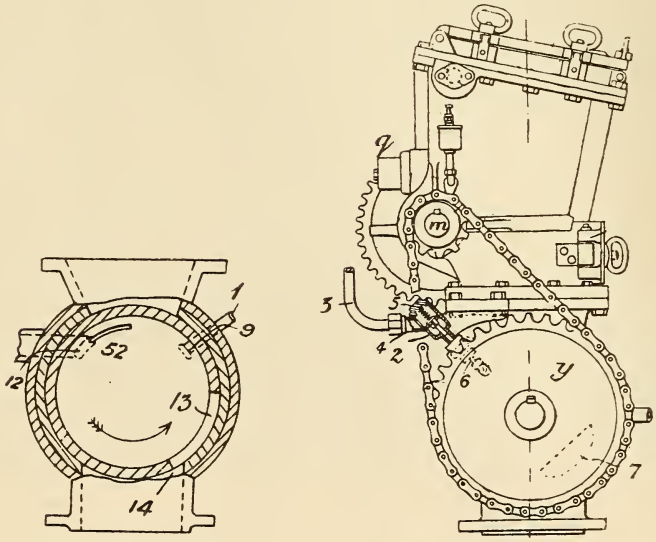


FIG. 19.—DETAILS OF CRUSHER AND DRUM OF STONE ASH EXPELLER

gate valve is built between the exit and the working part of the apparatus, to be closed only if repair should be necessary. An engine combined with an air compressor furnishes the driving power for the crusher and drum, and also the pneumatic supply for the same. Fig. 19 shows the apparatus more in detail. Fig. 18 shows the crushing jaws *i* and *h;* the latter is fixed, whilst the former is hinged at the top and reciprocates at its lower end by means of a three-lobed cam, which is keyed to the spindle *m*. A draw-back rod is actuated by a spring *P,* in case *q* keeps the face of the jaws always in contact with the cam face *r*. The shaft is driven by roller chain and chain wheels at a speed of 60 revolutions per minute, giving the hinged jaw about 180 double strokes per minute. There is an inspection door to give access to the lower part of the hopper, and the whole apparatus can be closed by a watertight cover. A water spray is provided to wash out and keep the hopper clean.

The revolving drum under the hopper is conical, and fits like a cock into its casing. The hollow drum is supported by two bearings, and the whole consists of one casting; there is but one opening *13* in this revolving cone, which coincides alternatively with the inlet and outlet of its casing. The chain wheel *y* receives power from the crusher spindle. To assist the expulsion of the ashes, compressed air is admitted into the drum by air pipe *3* and valve *2;* this valve is opened as soon as the drum has attained the position at which the air cannot escape out of the hopper; there is a tripper *7* on the chain wheel *y,* which opens the valve *2* just at the right moment once in every revolution; the air is then admitted by pipe *1* and the opening *10*. At the position of the drum as shown in Fig. 17 water is also admitted by pipe *16* and the spreaders *17* and *18,* which cause a spray and prevent the creation of dust. Fig. 19 shows an outside view, from which

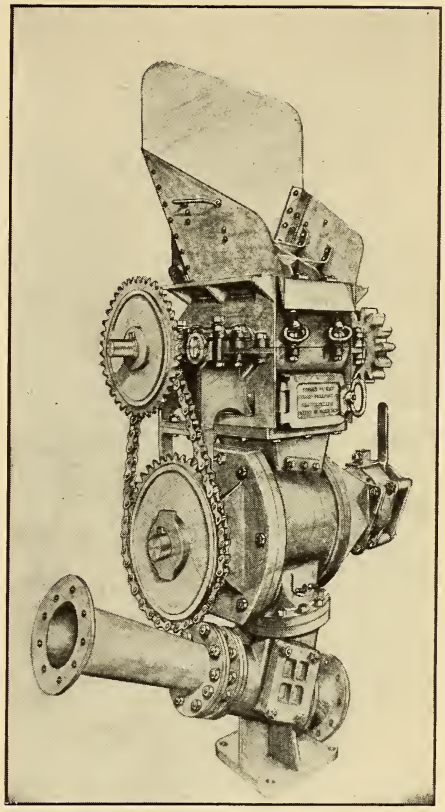


FIG. 20.—STONE'S PATENT HYDRO-PNEUMATIC ASH EXPELLER

the tripper *7* and the air valve can be better seen. In the sectional part of Fig. 19 the drum is shown in the position in which opening *13* is just beginning to discharge into exit *14;* the compressed air prevents the sea from entering whilst the ashes escape; just before opening *14* is closed again by the revolving drum a communication with the atmosphere is formed by opening *52* and pipe *12*.

The hydro-pneumatic underline ash expeller is similar to the last, and a general disposition is shown in Fig. 15. In this arrangement a stream of water, which is drawn from the sea by a centrifugal pump, is continually moving through a discharge pipe which passes underneath the expeller.

The ashes and other refuse are shoveled into a crushing hopper, whence they pass into a double-

ported revolving drum, similar to that above described, which alternately presents its openings to the hopper and to the moving stream of water beneath, so that the ashes are caught by the stream and carried, not overboard, but several feet clear of the ship's side, or bottom, according to the place from which they are discharged.

Both the air compressor and the centrifugal pump are coupled to a two-crank, single-cylinder steam engine, which is also used for driving the crusher and the revolving drum.

The ash discharge pipe may be either vertically downwards through the bottom of the ship, horizontally through the side, or inclined at an angle as shown in Fig. 15.

Both types of underline ash expellers are fitted with knife blades at the drum and its casting, to shear off any material which might find its way between the working surface; as well as with a safety action, by which the entry of extra hard material causes the breakage of a small safety pin and stops the machine. Upon the shearing of this pin the steam-driven compressor is immediately stopped by an automatic arrangement, which makes a steam governor unnecessary. These pins are easily replaceable, and a number are carried as spare parts.

All the later vessels of the British navy are now fitted with these ash expellers, as well as the most important of the liners, including those of the Cunard, White Star, P. & O., etc.

ALUNITE: A NEW SOURCE OF POTASH

By Guy Elliott Mitchell, United States Geological Survey

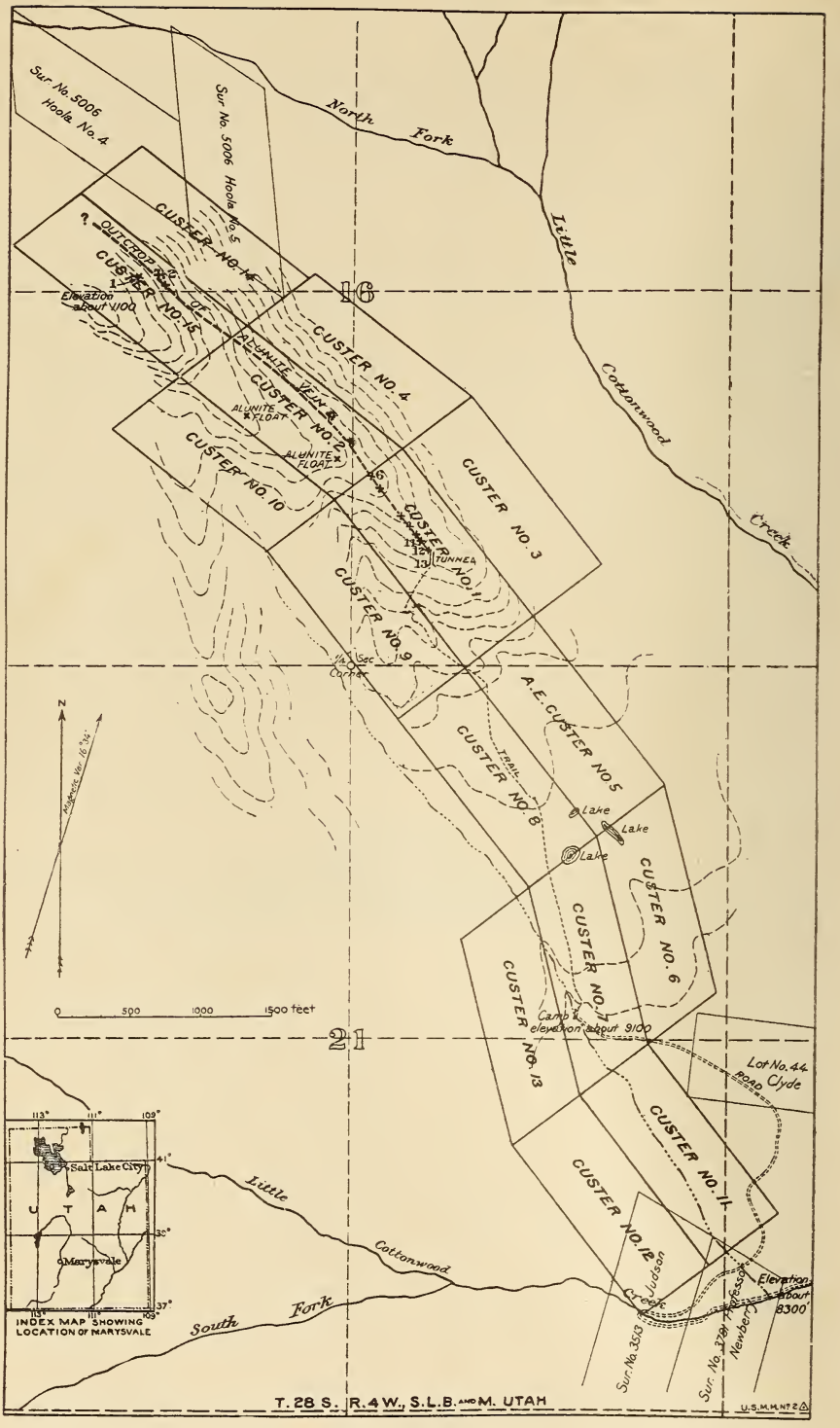
ALUNITE is a mineral which may come to our relief to a considerable extent in furnishing a supply of potash, for which necessary fertilizer the United States is now entirely dependent upon Germany to the extent of more than $16,000,000 a year. An important deposit of this mineral recently discovered in Utah is described by the United States Geological Survey as being developed with so favourable a showing that it promises to afford one source of the much-desired class of materials commonly referred to under the term "potash."

In the vicinity of Marysvale the peaks of the Tushar Mountains rear their white heads to a height of nearly 13,000 feet above the sea as prominent landmarks in Southeastern Utah. The Tushar range is a complex mass of sedimentary, volcanic and plutonic rocks, and near Marysvale in the prehistoric ages of the world was formed at least one and possibly other veins of this potash-rich rock which it is now proposed to develop into commercial potash. The new discovery was recently visited by geologists of the Federal Survey, and analyses have been made of the rock which show it to contain about 10 per cent. of pure potash (K_2O). While there are many rock deposits in various parts of the country which carry as much or more potash than the Utah alunite, the potash in them is almost without exception practically insoluble under any known commercial process. This is not true of alunite, which is easily treated and the potash made available as a plant food, and the statement of the Geological Survey that the Marysvale vein is at least 3,500 ft. long and varies from 6 to 20 ft. in width, extending downward to an unknown depth, is highly interesting. The Survey geologists who recently made an examination of the vein believe that it continues to a considerable depth, and, furthermore, that mining operations may develop into commercial propositions additional veins examined. Their report, which is being printed as a government bulletin,* conservatively estimates an average width of the main vein of 10 feet and a total tonnage of 300,000 tons of rock for each 100 feet of depth. The vein may, of course, pinch out at or before this depth; on the other hand, should it extend to a depth of 1,000 feet, which would be an easily minable depth, and assuming that other adjacent veins yield one-half as great a tonnage, there would be a total of 4,500,000 tons.

While alunite is not as high grade a source of potash as the sulphate or chloride salts obtained from Germany, it compares favourably with the German kainite salts; and last year the imports from Germany of kainite and manure salts into the United States were more than 500,000 long tons, valued at about $3,500,000. The potential value of the potash in such a tonnage as is estimated for this alunite deposit—4,500,000 tons of rock, yielding 450,000 tons of potash (K_2O)—at the present price of potash would be in the neighbourhood of $30,000,000.

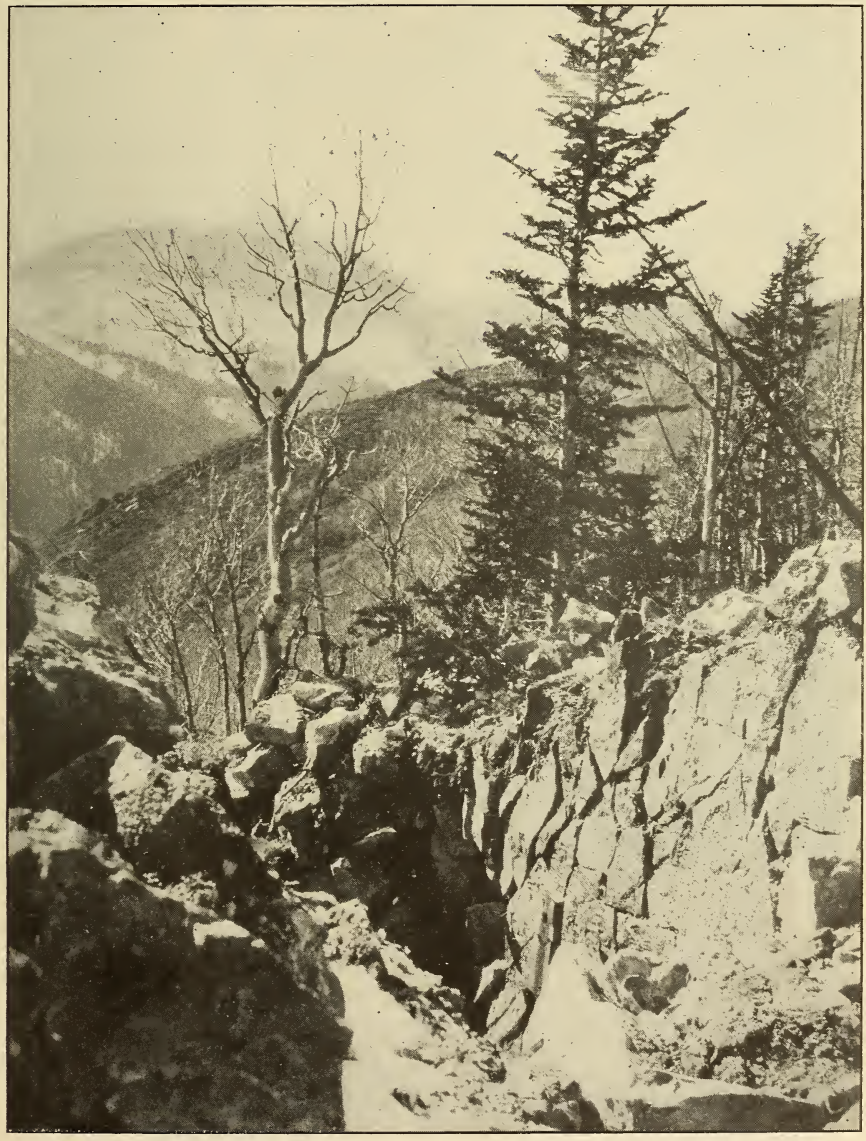
The alunite specimens which Geologist Gale brought back to Washington show a pinkish, fine-grained, crystalline rock, and the layman would examine a piece a long time

*Bulletin 511, U. S. Geological Survey.



MAP SHOWING THE PRINCIPAL GROUP OF CLAIMS LOCATED ON THE ALUNITE DEPOSIT NEAR MARYSVALE, UTAH

before suspecting that it possessed any greater value than that of, perhaps, good building stone. In handling a piece of this alunite, which appears for all the world such a rock as you might pick up along any roadside to throw at a vicious dog, and then considering it as a probable source of millions of dollars' worth of potash, one is most forcibly impressed with the worth of scientific knowledge. As a fairly educated citizen with a general grasp of human affairs, the writer feels himself on an equality, perhaps, with Mr. Gale; but when he realized, as he did all at once on handling this piece of rock, that he might have lived alongside it all his life and considered it common stone, while Gale would have seen millions in it—mining, and transportation, and manufacturing in-



ALUNITE VEIN NEAR MARYSVALE, UTAH. FISHER RANGE IN DISTANCE

PROSPECT CROSSING THE MAIN ALUNITE VEIN NEAR MARYSVALE, UTAH

dustries growing out of it, and ultimately increased crop production and abundance of human food, cheaper food, perhaps—and, moreover, that there are a hundred other similar Nature books lying open for him which to the layman are still only rocks, then he is forced to admit that the disciple of an exact science, such as geology, stands far higher than the man of general training. Indeed, in the case of the Marysvale alunite, this large vein was a quite familiar object to prospectors, and had been repeatedly located for small metalliferous values thought to exist; but it was not until last year that the true nature of the deposit

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was discovered. Specimens sent to the United States Assay Office at Salt Lake were later forwarded to an Eastern chemist, who recognized the real value of the material. It may be mentioned here that Geologist Gale made a discovery last year in Montana, not far from Butte, of a deposit of phosphate rock containing millions of tons of this likewise necessary fertilizer—rock which probably thousands of miners and prospectors had glanced at and cast aside as worthless.

Alunite, according to the Geological Survey, is readily converted to sulphate of potash by a comparatively simple process of roasting and leaching. A reduction treatment that has long been employed commercially abroad may doubtless be adapted to the American deposits; and while it is stated that the Marysvale deposit, so far as now known, is not of such magnitude as to afford a source of all the potash salts now consumed in the United States, it may prove to be an important factor in providing an American supply that will, perhaps, be especially available to Western markets. Possibly the greatest importance of the commercial development of this deposit will be in the added stimulus it may afford to exploration of other similar deposits of this mineral, especially in the Marysvale region.

The principal claims located on the Marysvale alunite deposit are known as the Custer group, the first location made expressly for the alunite having been staked January 1, 1911. Enough prospecting and actual development work has been done on the Marysvale deposit to show a very large tonnage of alunite "in sight"; and while this particular vein cannot possibly furnish the United States with anything like an adequate supply of potash, it is not reasonable to suppose that this is the only commercial deposit in the United States. Indeed, a large number of alunite deposits have been noted by different government geologists in widely separated localities; but since no particular commercial importance had heretofore been attached to the mineral, estimates of the tonnage of the deposits are not available. You cannot get a scientist to make a mere guess, but the probability is, however, that the known deposits of alunite, to say nothing of those which will be discovered, contain many million tons of this potash-rich rock. Alunite, while not a common mineral, on the other hand is by no means an uncommon one, and it is mined in large quantities in many foreign countries. The development of the alunite deposits in the United States should at least have the effect of reducing the exorbitant price now charged American farmers by the German potash producers, who hold a world's monopoly of this necessary fertilizer.

Until recently, the Geological Survey report states, there has been no incentive to search for alunite, and most of the known occurrences in the United States have been noted incidentally by geologists who were making general geologic studies, and that "there is little doubt if prospectors had explored for alunite with the same diligence that they have shown in their search for metallic ores a far greater number of deposits would be known." The report, however, specifically mentions a number of other alunite deposits. The practical results of the Marysvale enterprise in solving, or at least helping to solve, the American potash problem, will be watched with no little interest.

A comparatively simple field test for alunite is given by the Geological Survey, the necessary material for which includes, in addition to the miner's or prospector's usual outfit, only a small quantity of barium chloride, which can be carried in a bottle or a cartridge. The Survey also sounds a note of warning to prospective investors in alunite properties, since the promoters of more than one get-rich-quick potash proposition have already endeavored to take advantage of the present public

interest in the potash subject by offering gold bricks to the unsuspecting. It may be mentioned in this connection that Congress has specifically authorized, and appropriated money for, both the Bureau of Soils and the United States Geological Survey to prosecute investigations of possible sources of American potash, and these two bureaus stand ready to give the public the benefits of any information they possess, both potash prospectors and prospective purchasers of alleged potash discoveries.

A recent significant phase of the potash search is the message which President Taft sent to Congress urging the need of immediate legislation to enable the Executive at any time to withdraw from entry, and perhaps monopoly, any public lands found to contain valuable potash or nitrate deposits—an authority similar to that which Congress has approved with reference to phosphate lands.

THE DIRECT DRIVING OF MINING PLANT BY INTERNAL-COMBUSTION ENGINES

DISCUSSING ESPECIALLY THE OPERATION OF COLLIERY FANS

By A. Vennell Coster

THE present time seems opportune for the consideration of some of the various means for increasing the efficiency of the operations of collieries. The air is filled with labour unrest; coal strikes are to be apprehended, and the question of the improvement of machinery is of immediate importance. It has been demonstrated that the cost of the direct development of power from the gas engine is only about one-half of that derived from steam. If this can be shown to be true in other countries, as it has been demonstrated in the German collieries, where the gases from coke ovens and blast furnaces have been utilized for the full working of the colliery plants, surely the proprietors of Great Britain and other countries may adopt it, allowing a larger margin of profit to the workers, the majority of whom run great risks in their subterranean calling.

The gas engine has proved itself most capable for the driving of electric generators, whether for the simple, direct-current type, or for the alternate current in parallel. In fact, for nearly all purposes in connection with colliery working gas power may now be safely adopted; but, in the writer's opinion, we have not as yet got to the stage in which *direct driving* of all colliery appliances may be undertaken.

The author does not wish to advocate impracticable schemes, nor plans which may in any way be considered doubtful, such, for instance, as the onerous duty of hauling and winding, in which the power and speed must be held under the strictest and most accurate control. In such cases it is the writer's opinion that the gas engine cannot be used in direct drive satisfactorily, but, with somewhat reduced efficiency, it may be employed through electric motors, air compressors or water motors. For all underground service the gas engine must act through intermediate systems of this kind, and can do so with perfect reliability and assured success.

For many purposes the single-cylinder engine, such as shown in Fig. 1, with one impulse for every two revolutions, may be installed; but where very close running is necessary for large powers, the double-acting gas engine, with either two or four cylinders, as shown in Figs. 2 and 3, is to be preferred. Such engines can be arranged to start automatically against a full load by means of compressed air, each cylinder being fitted with an automatic admission gear. It may be of interest to note that an engine similar to that shown in Fig. 3 is now being installed in Yorkshire, where continuous running is required, with three shifts of men every twenty-four hours.

It is the primary intention of the writer, however, to deal particularly with the direct driving of colliery ventilating fans by the gas engine, and to give exact details of an installation in which initial failure ended in complete success, a result which can be attained in all cases with direct gas-driven fans.

In the past there has naturally been much well-founded prejudice against the use of gas engines for such onerous duty as the driving of continuously-running colliery fans. The steam engine, with almost a century

of experience to back it, has proved itself a capable and reliable prime mover, whereas the gas engine, with not so long an experience and not so well understood, has undoubtedly made considerable headway toward that stage of perfection which will make it acceptable to the average colliery proprietor, and thus ought to be more generally known.

At the present time, when it has become absolutely necessary to cut down working expenses to a minimum, and when every colliery possesses tons of unused coal waste and dust, or millions of cubic feet of gas from coke ovens and the like, it seems that a discussion of the methods by which these hitherto wasted fuels may be used directly for driving purposes in the internal-combustion engine may be of service to the colliery engineer. It is essential that the engine should be designed for continuous running, a requirement already made by many other services. The writer knows of many large gas engines which are operated regularly for 98 per cent. of the time year in and year out at a minimum of cost and trouble, and has grounds for saying that the gas engine can do, and has done, equal work with the steam engine at considerably under two-thirds the total working cost; but its reliability can be guaranteed only so long as the gas engine is never overloaded nor overspeeded.

Many gas engines have already been installed for driving colliery fans, of both high and low speed types, by means of ropes, and such an installation, of a heavy rope drive, transmitting power for colliery work from an internal-combustion engine through a Heywood & Bridges friction clutch is shown in Fig. 4. This method makes a very elastic coupling, but has the following disadvantages:

1. There is a loss of 7 to 10 per cent. of the power in the rope drive, due to friction;

2. There is the wear and tear upon the ropes themselves;

3. There is required for an economical rope drive not less than 30 feet between centres, thus taking up considerable space.

The ideal system, of course, is a direct drive to the fan itself. The above disadvantages then disappear, but there is still an interesting problem awaiting solution—that is, the best method of coupling the impulse drive of the gas engine to the shaft of the fan, which must run with un-

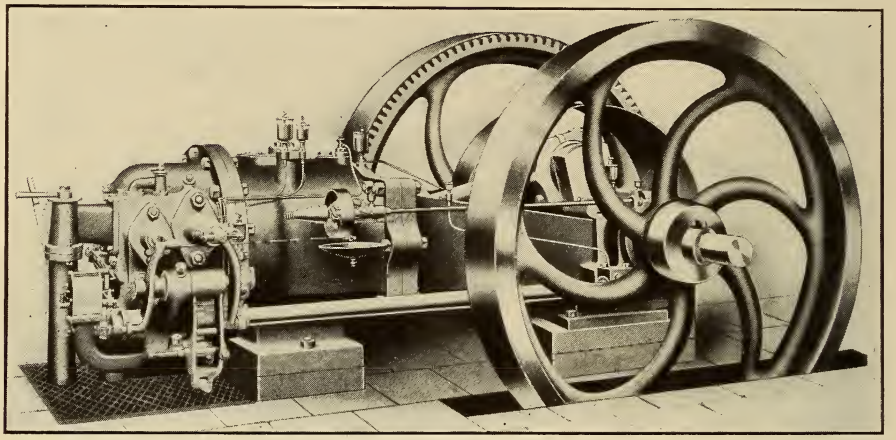


FIG. 1.—GAS ENGINE INSTALLED FOR DIRECT DRIVING OF CAPEL FAN AT DON PEDRO MINE, YORKSHIRE

This engine is supplied with coke-oven gas, developing 150 horse-power. Crossley Bros., Ltd., Manchester.

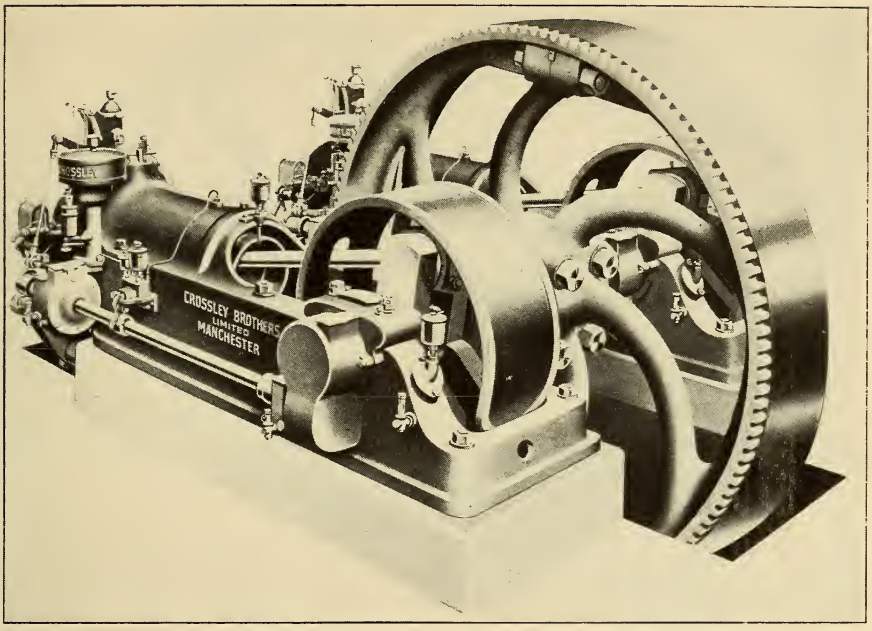


FIG. 2.—TWO-CYLINDER GAS ENGINE. CROSSLEY BROS., LTD.

varying regularity. This problem, and others of equally interesting nature connected with colliery fans, have not been dealt with practically in any technical publication, and there appears to be no technical literature upon the subject, the makers of such machinery keeping their practical experience very much to themselves.

It is assumed in engineering circles that if the fan is carefully balanced upon a rigid shaft, with good long bearings to support it, satisfactory operation will be assured under normal conditions, the torque and the stresses on the bearings both being practically constant.

Now, although direct driving is to be preferred when the driver is adapted to the driven, it remains that the rope drive is a very popular alternative among mine managers, upon the assumption that they know a great deal more about the nature of the drive than the engine and fan manufacturers put together.

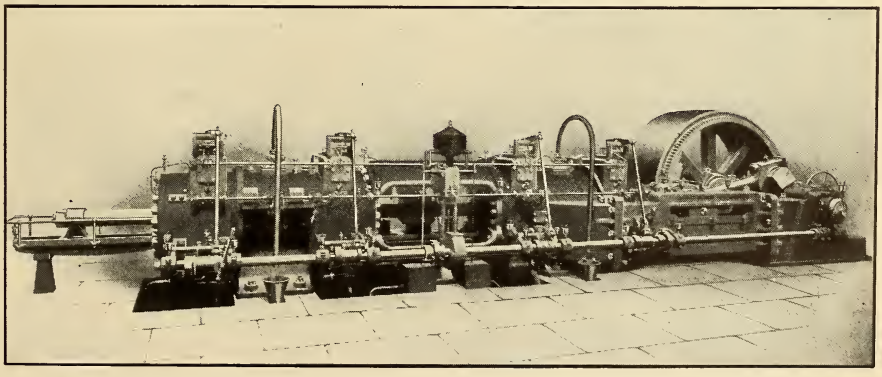


FIG. 3.—DOUBLE-ACTING FOUR-CYLINDER GAS ENGINE. CROSSLEY BROS., LTD., MANCHESTER

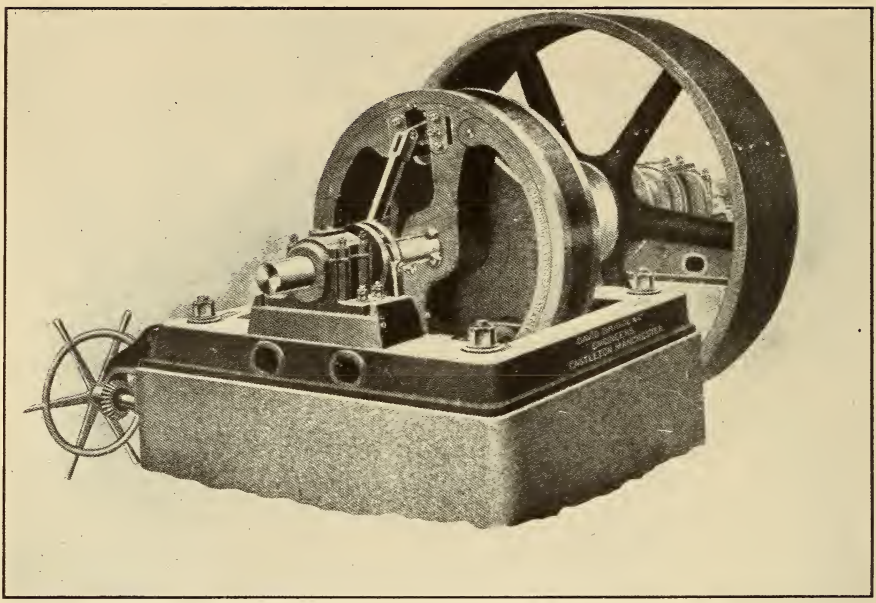


FIG. 4.—HEYWOOD & BRIDGE FRICTION CLUTCH FOR USE WITH ROPE DRIVE AND GAS ENGINE. DAVID BRIDGE & CO., MANCHESTER

In order to examine the question definitely, the following account of the troubles encountered with a direct driving system and its final success is given. The writer was called in to assist in the solution of a problem which will be considered in detail.

A large Capel fan had been installed at a colliery to exhaust about 200,000 cubic feet of air at 3¼ inches water gauge, the fan being 16 feet in diameter by 4 feet 6 inches wide, with eight main delivery vanes, the dead weight of the fan being 7½ tons. When running at 160 revolutions per minute the fan has in itself a stored energy of about one million foot-pounds. As there was a large amount of gas blowing to waste at the colliery, it was decided to drive this fan directly by a gas engine. The proposition was stoutly opposed by the designer of the fan, as he said the conditions for satisfactory driving could not possibly be made, nor had such a thing ever before been attempted. The matter was submitted to a large firm of engineers, however, and, upon investigation by experts, it was decided that it could be done. A single-cylinder Otto-Crossley gas engine, developing about 150 maximum brake-horse-power at 160 revolutions, using coke-oven gas, was decided upon, and as the foundation upon which the fan rested could not be satisfactorily united with the foundation for the gas engine, it was decided to connect up the crankshaft of the gas engine to the fan shaft by means of a flexible coupling. The fan, with an efficiency of more than 70 per cent., required 140 brake-horse-power, and a flexible coupling capable of transmitting fully twice this amount of power was fitted. It may be noted, in passing, that the average calorific value of the coke-oven gas to be used equaled 560 B. T. U., hydrogen being more than 43 per cent. and methane more than 31 per cent. At the trial a very extraordinary thing happened. Like an egg under the foot of an elephant the flexible coupling broke into a dozen pieces before it had made as many revolutions.

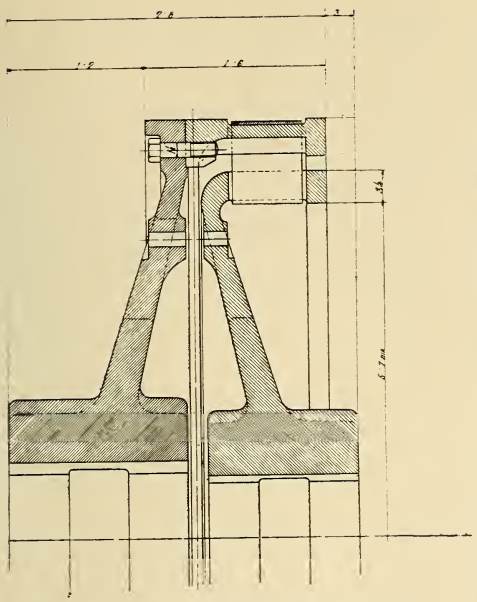


FIG. 5.—SECTION OF FLEXIBLE COUPLING SHOWN BELOW

The writer has no desire to decry the usefulness of flexible couplings, for thousands of them are in use for a great variety of drives and duties, with complete satisfaction; but in this particular instance the installation was apparently a mistake. A second coupling, 50 per cent. stronger than the first, and then a third coupling, 100 per cent. as strong as the first, were fitted, and, with slightly longer intervals, these were destroyed in a similar manner. The matter began to look serious; the conditions were evidently little known, and it appeared as if the fan and the gas engine were difficult companions, not to be reconciled. At this juncture it was suggested by the builders of the gas engine that the engine and house should be shifted to accommodate the more practicable rope drive; but the colliery owners were obdurate, insisting either that the positive mechanical drive should be used or the gas engine removed and themselves indemnified for all losses incurred. Mining engineers, like other men, do not like experimental engineering unless they themselves are the experimenters.

It was then suggested that a friction clutch should be used, since it appeared impracticable to put in a

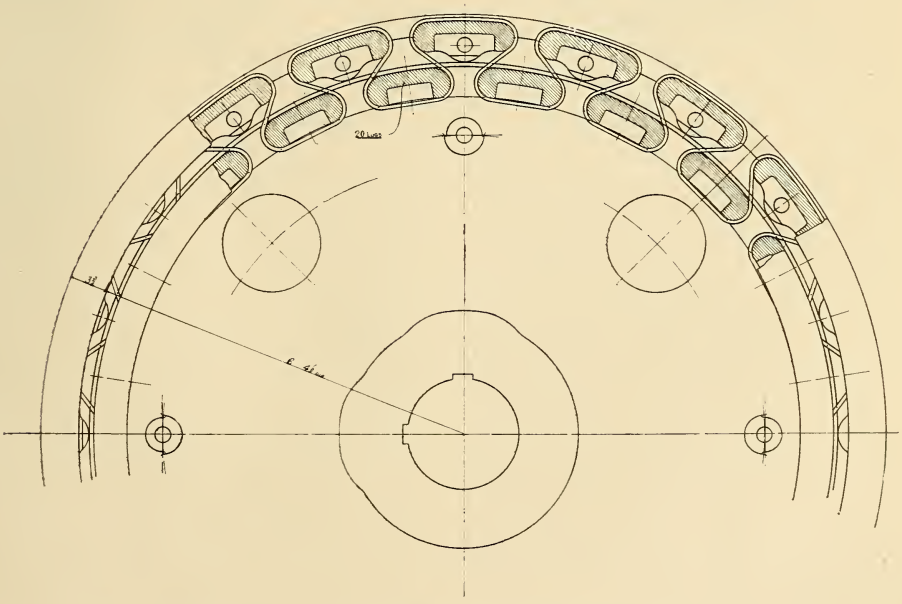


FIG. 6.—FLEXIBLE COUPLING FOR CONNECTING GAS ENGINE TO DRIVEN MACHINERY.
CROFT & PERKINS, LTD., BRADFORD

solid coupling for several reasons, but particularly because of the division in the foundations.

A first-class firm, making a Weston type of friction disc coupling, was called in, and a clutch capable of transmitting 400 horse-power was fitted to the shaft of the 150 horse-power gas engine. By means of this friction coupling it was possible to start up the gas engine and gradually bring the fan up to full speed by easy stages. This coupling lasted for five weeks, but by the end of that

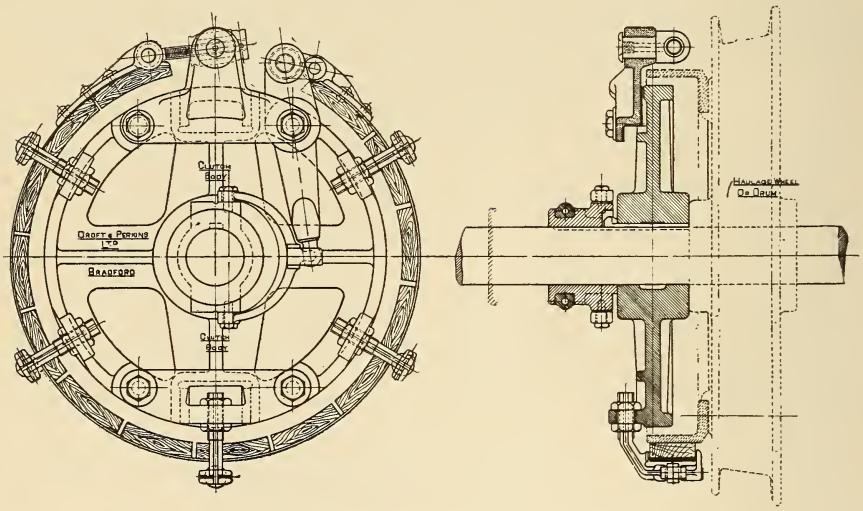
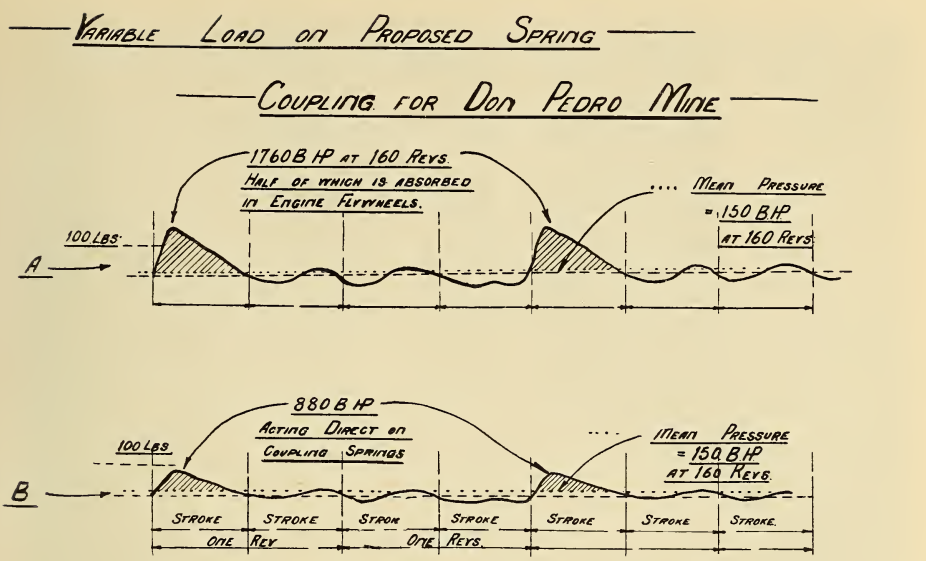


FIG. 7.—BAND FRICTION CLUTCH FOR POWER TRANSMISSION IN MINING MACHINERY.
CROFT & PERKINS, LTD., BRADFORD

time the internal plates were ground and torn to pieces. The oil which had been injected boiled out in the form of heavy vapour, while accompanying the disintegration were shocks and mysterious sounds, indicating the heavy strains which passed and repassed between the engine and the fan. We were now beginning to learn something. The alternations from the power stroke in the gas engine and the vibrations in the fan as each blade passed the air aperture ultimately started a flaw in the engine crankshaft end. Things were going from bad to worse.

As a last resort, it was suggested that a new patent friction clutch, recently introduced and extensively advertised in the engineering world, might solve the problem. The leading expert of the makers came down and was fully informed of the disastrous history of the case and warned to make ample provision. He suggested a friction clutch easily capable of transmitting 500 horse-power and a heavier shaft in the gas engine. These were in due course fitted, and although when running it was noticed that there was a constant slight slip in the clutch, which no amount of pressure on the actuating gear could take up, still in every other respect the clutch appeared to be a success. The installation was now put to work, the fan being started at midnight on Sunday and run continuously night and day until the next Saturday midnight; but, unfortunately, as the days passed, the slip in the clutch increased. Adjustments were made, heavier springs fitted, but at the end of three weeks the ominous slip developed into a horrible grind, followed by sounds resembling those of a gigantic coffee mill, and in a few hours the fan came to a standstill. By this time, as can be imagined, the patience of the colliery



A Shows the Tangential Effort on the Engine Crank Pin the Plus energy marked //// being absorbed in Equal Parts by the Engine Flywheels and 16'-0" Dia Air Fan - so that half the Plus energy = 880 B HP passes through the Spring Coupling once every two Revolutions as shown above at B

FIG. 8.—DIAGRAM SHOWING FORCES TO BE HANDLED IN TRANSMITTING POWER FROM GAS ENGINE TO FAN AT THE DON PEDRO MINE

proprietors had reached its limit. There was nothing for them to do but to scrap the engine and demand compensation. At this point the makers of the clutch pressed to be allowed to put in a heavier friction clutch, and they were permitted to do this. A huge clutch, capable of easily transmitting 1,000 horse-power, was then fitted, and every possible precaution taken, both in the keying and the adjustment, to prevent any possibility of failure.

To cut a long story short, this clutch ran barely six weeks, and then ended like its former and weaker predecessors, succumbing to the extraordinary and mysterious stresses that were alternating between the engine and the fan and the fan and the engine.

The writer had the opportunity of examining the fractured portion of this friction coupling and found that of twenty steel bolts, 1⅛ inch in diameter, which held the external portion of the discs, thirteen of them had their heads pulled completely off. These had undoubtedly succumbed to the expansion of the external parts, due to excessive heating. This clutch, admirable for other purposes, was evidently out of place here. Of the forty internal discs, practically all of them had been ruptured at the boss, their projections having been torn off and forced in between the movable discs.

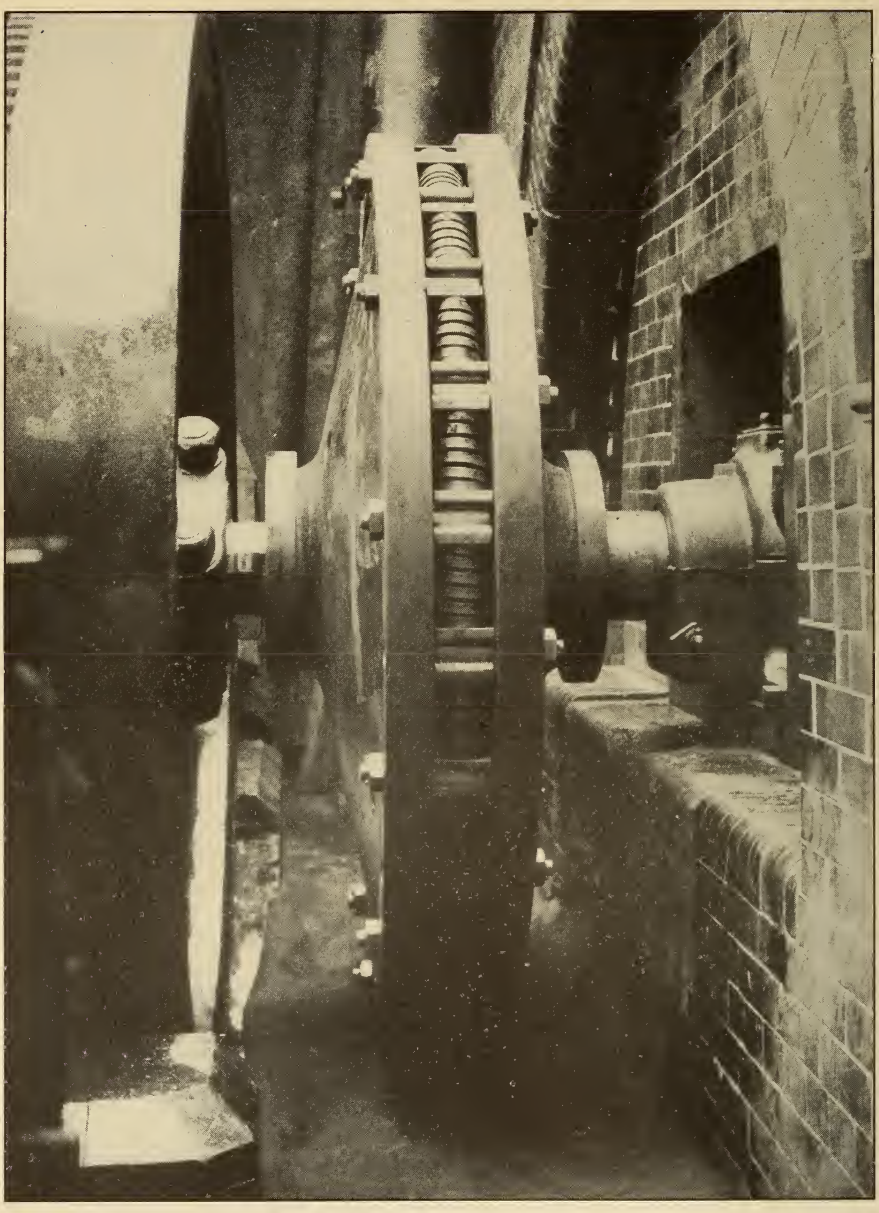


FIG. 9.—SPRING COUPLING FOR TRANSMITTING POWER FROM GAS ENGINE TO FAN AT THE DON PEDRO MINE.
A. VENNEL COSTER

After this collapse a meeting of the directors of the two companies involved took place, and it was decided that the drive was impracticable.

Legal proceedings were threatened which would have involved both parties in exceedingly heavy expense. At this juncture the writer had the opportunity of investigating the matter. A solution did not seem probable; but since the problem had been such a costly one it appeared worth while to obtain data, so that present mistakes might be avoided in future installations.

FIG. 10.—CONNECTING UP THE 150-HORSE-POWER GAS ENGINE TO THE CAPEL MINE FAN. DON PEDRO

Studying the design and duty of the Capel fan with the meagre information at hand, it appeared that one of the outstanding features was that at full speed the fan would resist any cyclical variation. Approximately ten miles of air-ways and shafts in the mine were delivering up their foul air through the fan at such a speed that about 200,000 cubic feet per minute were delivered to the atmosphere. Not only was the angular velocity of the fan constant, but through the shaft it would transmit

a heavy vibration or pulsation as each vane delivered its contents. On the other side of the coupling there was the Otto cycle gas engine, an impulse machine fitted with fly-wheels having, at 160 revolutions, a stored kinetic energy of 950,000 foot-pounds, which limited the inequality to about 1/30.

Now it will be noted that the stored energy of the fan is approximately equal to the stored energy of the engine fly-wheel, so that on the power stroke the plus power to be stored for future service would pass about half into the engine fly-wheel and the other half through the coupling into the fan. This abnormal flow of energy occurring once in every two revolutions through the coupling was roughly calculated to be equal to about 900 momentary horse-power, and the writer felt that the only way to reduce it would be to fit heavier fly-wheels upon the engine. The cramped position of the engine and the fact that no additional work or alteration would be allowed to the foundations or engine house precluded making this change. The question then arose, Could a coupling be designed which would connect the immobile fan satisfactorily with the mobile engine?

The diagram, Fig. 8, shows approximately the variable load transmitted through the coupling and also the varying power in the gas-engine cylinder. In the latter the peak momentary load amounts approximately to 1,800 brake-horse-power; stated in this manner as horse-power makes it more easily comparable with the normal power of the engine.

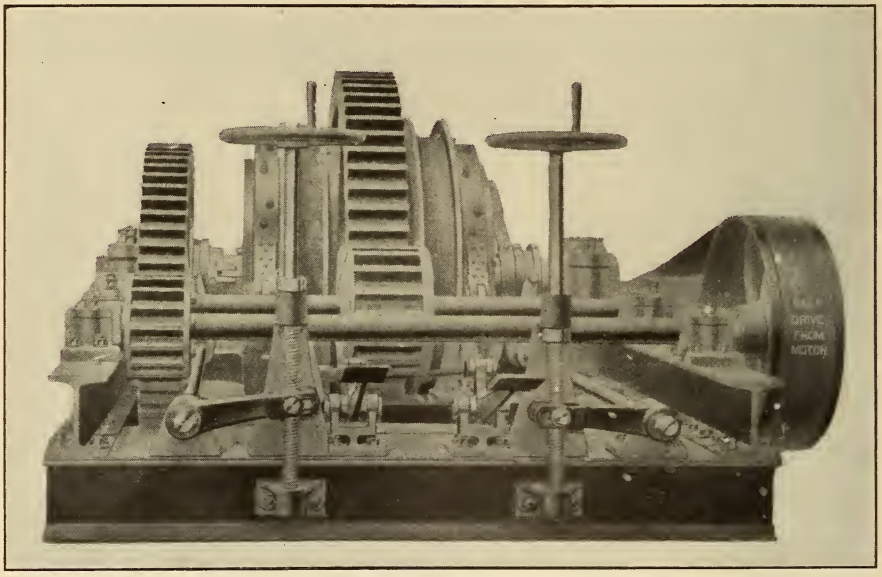


FIG. 11.—ARRANGEMENT OF WIRE ROPE MINE HAULING GEAR. DAVID BRIDGE & CO., MANCHESTER

It may be interesting to know that a solution of the problem was found, and that this identical engine and fan have now been running for a number of years with perfect satisfaction to the owners. As is usual in mine practice, the fan is started up about midnight on Sunday and runs continuously night and day until the following Sunday morning. The saving in fuel cannot be correctly estimated, as the steam for driving the now discarded fan was drawn from a battery of Lancashire boilers which supplied the power for the hauling gear, air compressors and other mining

plant. It was found that at least four men could be taken off the boilers, and, remembering that the gas was practically a waste product from coke ovens, the reduction of expense could not be less than £500 per annum.

The design made to cover the foregoing conditions is shown in Fig. 9, and, having a number of original points, it was patented. As can be seen, it is simply a spring coupling, and is composed of two similar discs of large diameter, with alternate projecting heavy studs, between which heavy section coils, initially pressed to a predetermined amount, are held between shoes mounted upon the studs. An important feature of this coupling is the fact that the springs are equally divided into action and reaction springs, and each spring takes absolutely the same load as every other spring. The method of obtaining the initial compression is by means of tapered necks of the simplest description, so that all of these springs can be easily and speedily removed and replaced when required. When first testing the coupling, the writer fixed an indicator pencil, attached to one of the discs and bearing upon the other. By this means the compression of both action and reaction springs was indicated by the movement of the pencil before or after the normal starting point. Working from the known load to compress each spring at so many pounds per inch, the momentary load, due to the passing of the engine energy to the fan, could be determined, and the extraordinary reading appeared to prove that close on to 2,000 horse-power had been momentarily transmitted by this coupling. No doubt the springs, due to the impulsive load, would overpass the correct compression, but this does not, in the writer's opinion, fully explain the abnormal load; perhaps some reader can suggest the solution.

Fortunately, the ample proportions of the coupling precluded any failure due to any part of it being overloaded, and after three months' continuous running without the least trouble or noise or undue friction the installation was taken over by the colliery proprietors, and is running to this day. Fig. 10 shows the engine being finally connected up. This special spring coupling has, therefore, proved that a single-cylinder gas engine with a normal irregularity for industrial purposes can be easily and economically connected to any type of continuously-running mine fan, and that by its means a higher efficiency and greater economy of power and space and reduction of wear and tear can be obtained than by any other means.

THE NEW CANALIZED CHANNELS IN THE DETROIT RIVER

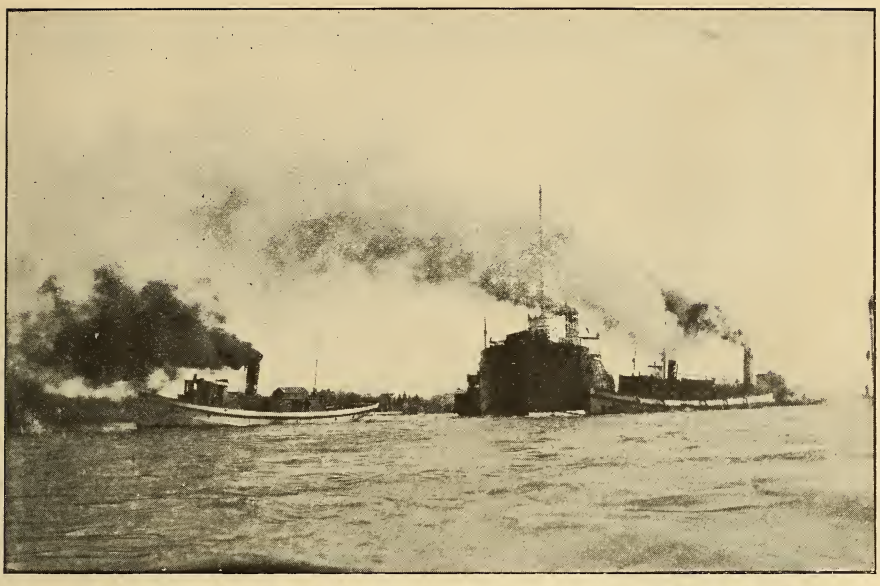
By James Cooke Mills

WITHIN the present generation, when gigantic engineering works have fairly astounded the world, the United States have given Canada immensely valuable waterways along the northern frontier, and were eager to do it. Why the government at Washington should have spent more than $10,000,000 for the improvement of river channels lying almost wholly in Canadian waters and beyond its jurisdiction or control, is a question not open to much argument; but the facts surrounding this unusual expenditure should be thoroughly understood by the people of both nations. Some may say the project was carried out in evidence of a broad international policy, and others may contend it was merely a plan of expediency, for the easy solution of engineering problems. While both of these reasons are true in a measure, the real reason for going on to foreign ground in carrying out this great engineering project was simply a matter of economics. There was no sentiment about it; it was purely a matter of business, a question of efficiency; to spend $10,000,000 to save hundreds of millions to the commerce of our country.

This great work, which has been under way for thirty-seven years, is almost completed, almost ready to afford adequate navigation in the straits for the enormous commerce of the Great Lakes, a navigation which is free and open to the world without hindrance or tolls. The greatest benefits to be derived from these deep ship channels will, of course, be realized by the United States, whose splendid lake marine forms a double procession of heavily laden freighters, railroad liners, and passenger steamers, and is one of the wonders of America. Canada, in accepting these widened and deepened channels, will enjoy the same benefits to the full extent of her limited merchant marine engaged in the upper and lower lake commerce. The waters of greatest value to her shipping are Lake Superior, Georgian Bay, Lake Ontario and the St. Lawrence, because the economic route from Fort William and Port Arthur to Montreal is by the way of Georgian Bay ports, and not by the way of Lake Erie and the Welland Canal. Her shipping, moreover, is owned and controlled very largely by the transcontinental railroads whose lines cut directly across Ontario to Lake Ontario and the St. Lawrence.

Although Nature has lavished her richest stores on the lake country, and given it a great highway of commerce, numerous handicaps to free navigation of connecting straits were interposed to test the genius of man. From the time of the discovery and early exploration of the lower straits to the present, navigation of their tortuous and rock-bound channels has always been difficult and attended with hidden dangers. In August, 1679, when La Salle and his faithful followers in the *Griffin* sailed up the broad stream, and named it Detroit, the swift and treacherous waters were almost insurmountable; and Hennepin, in his narrative of the expedition, relates that they were three days in coming to the Lake St. Clair, a distance of only twenty-eight miles. He was so impressed with the beautiful scenery of the straits that he wrote:

"The straits are thirty leagues long bordered by low and level banks, and



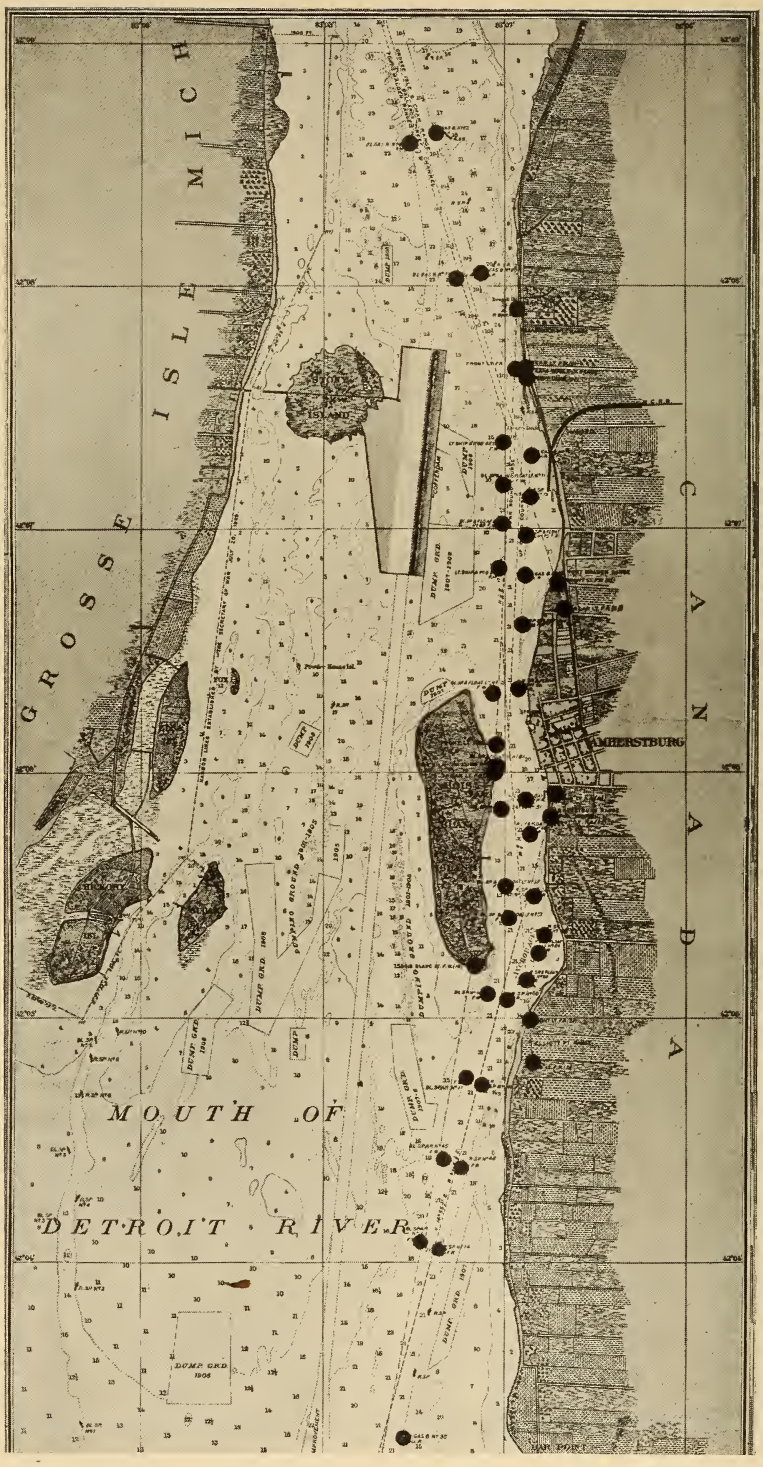
FREIGHTER AGROUND IN LIMEKILN CROSSING, ABOUT 2 FEET OUT AT BOW. FOUR TUGS WORKING TO RELEASE HER

navigable for their entire length; that on either hand are vast prairies extending back to hills covered with vines, fruit trees, thickets, and tall forest trees, so distributed as to seem rather the work of art than of nature. . . . The inhabitants who will have the good fortune to some day settle on this pleasant and fertile strait will bless the memory of those who pioneered the way, and crossed Lake Erie by more than a hundred leagues of unknown navigation."

Upon reaching their head at the outlet of the lake of the Hurons, they found the current so swift that they resorted to the expedient of towing their vessel along the shore by manual strength. The historian further declares that the waters ran almost as swift as in the rapids of the upper Niagara, where towing had been employed to bring the little vessel of sixty tons to Lake Erie.

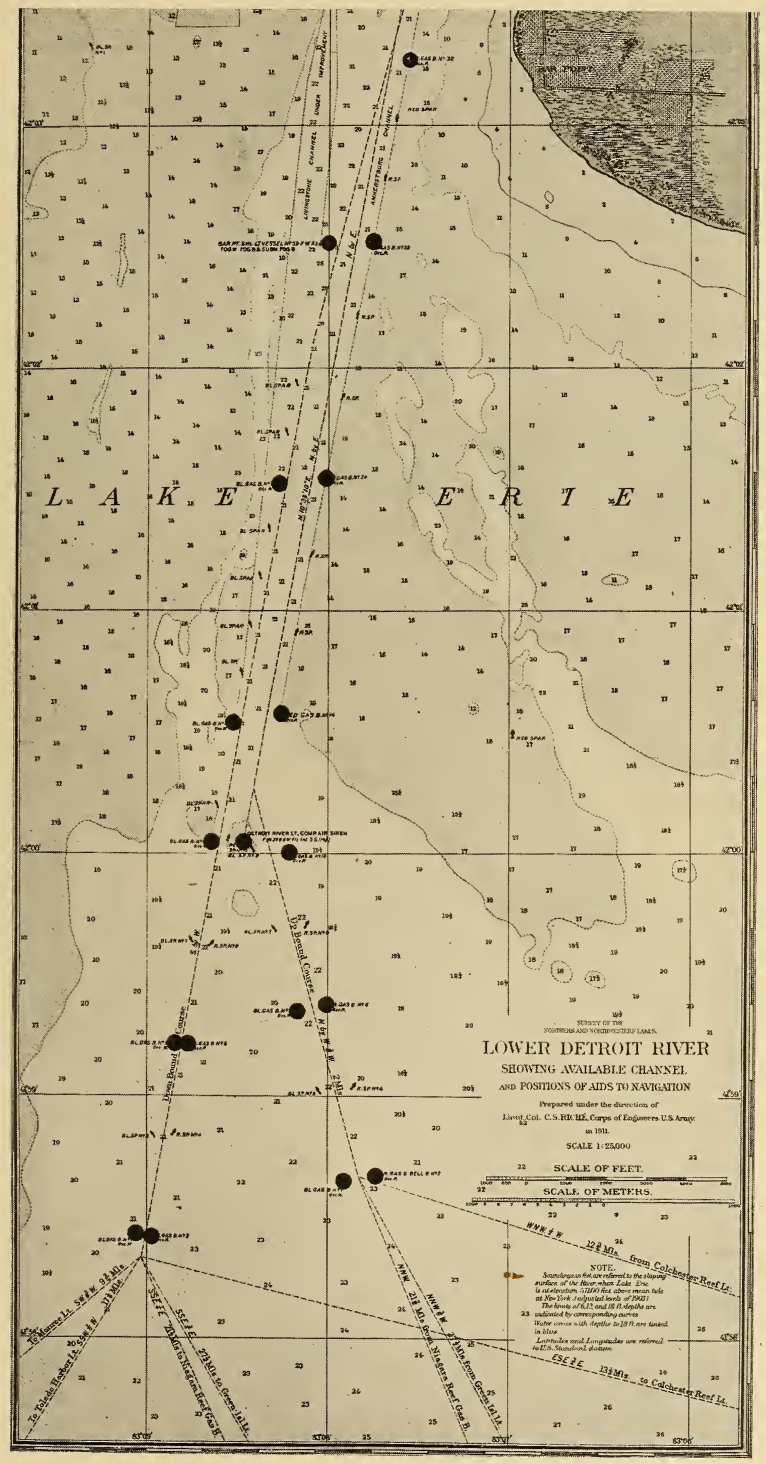
The boundary line between Canada and the United States was first established by the Treaty of Paris, which was signed on Sept. 3, 1783. It followed the *middle* of the Detroit River through its entire length. But the Treaty of Ghent, executed in December, 1814, established the line as following the middle of the deepest channel in the straits. A definite line, however, was not laid down and mapped until August, 1842, and the map filed in the Department of State. This line runs to the west of Bois Blanc Island and east of Grosse Isle, thence west of Fighting Island and back along the Canadian shore to Lake St. Clair. Under the terms of this treaty the boundary line was so located that all improvements afterwards made by the United States to 1907 were entirely in Canadian waters. The best sailing channel lay east of Bois Blanc Island, and naturally the ship channel followed that course, and was improved under successive projects.

The distance from Detroit to deep water in Lake Erie is about twenty-four miles, but the section included in these various projects in the last half of this distance. From the lower end of Fighting Island the natural watercourse veers toward the Canadian shore, and continues over a rocky bed with tortuous turns to the mouth of the river. This stretch, about twelve miles long, is known as the Amherstburg Channel, and floats the greatest



MAP OF THE LOWER DETROIT RIVER, SHOWING AVAILABLE CHANNEL AND POSITIONS OF AIDS TO NAVIGATION

Upper portion; see opposite page for lower portion


L A K E E R I E
LOWER DETROIT RIVER
SHOWING AVAILABLE CHANNEL
AND POSITIONS OF AIDS TO NAVIGATION
Prepared under the direction of
Lieut. Col. C. S. RICHE, Corps of Engineers U.S. Army
in 1911.
SCALE 1:25000
SCALE OF FEET.
SCALE OF METERS.
NOTE.
Soundings on flat are referred to the sloping surface of the River when Lake Erie is at elevation 572.00 feet above mean tide at New York, adopted levels of 1901.
The levels of 6, 12, and 18 ft. depths are indicated by corresponding curves.
Water areas with depths to 18 ft. are tinted in blue.
Latitudes and Longitudes are referred to U.S. Standard datums.
NNW ¼ W 12¾ Mls. from Colchester Reef Lt.
NW ¼ W 21¾ Mls. from Colchester Reef Lt.
SSE ¼ E 27 Mls. to Colchester Reef Lt.
SSE ¼ E 13¾ Mls. to Colchester Reef Lt.
To Pelee Harbor Lt. S 84° W 9¼ Mls.
To Pelee Harbor Lt. S 84° W 21¾ Mls.

MAP OF THE LOWER DETROIT RIVER, SHOWING AVAILABLE CHANNEL AND POSITIONS OF AIDS TO NAVIGATION

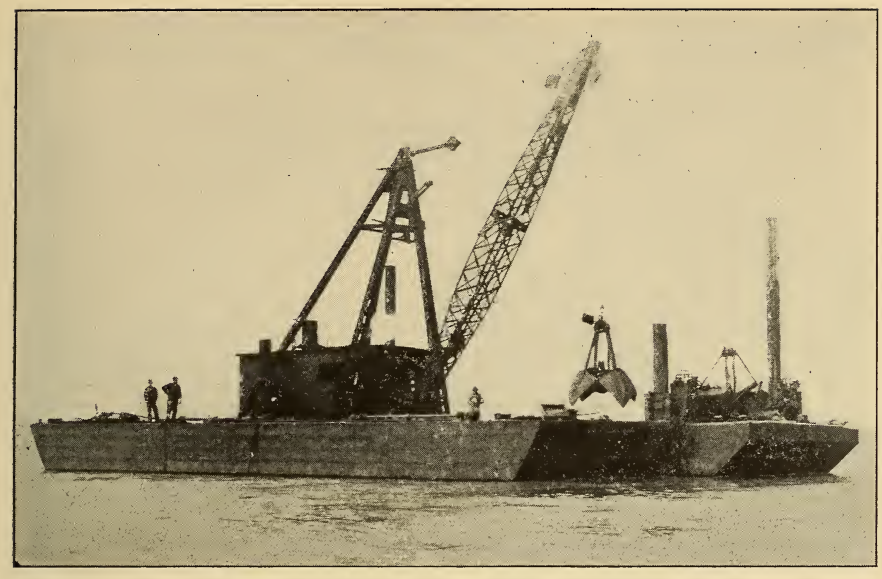
Lower portion; see opposite page for upper portion

commerce of any waterway in the world. Originally it was divided into five sections, which, beginning at the upper end, were designated as Ballard's Reef, Limekiln Crossing, Bois Blanc Range, Amherstburg Reach, and Hackett Range. The shallowest part of the channel was along the Limekiln Crossing, where the depth ranged from thirteen to fifteen feet, according to the stage of water in Lake Erie. Above and below the limekilns there was ample depth for all needs of commerce, but the winding channel and swift current rendered navigation extremely dangerous.

The first project to improve this channel by deepening and removing the overlying obstructions was undertaken by the United States in 1874. Even at that time the freight movement through the Detroit was large and increasing rapidly. It amounted to about 20,000,000 tons annually and comprised lumber and other products of the forest, salt, stone, coal, grain, and general merchandise. The shipping was composed of steam barges and their tows, "rabbits," a modified type of the barge, schooners, railroad liners, and side-wheel steamboats, the average cargo capacity of which was less than five hundred tons. These vessels drew anywhere from ten to fifteen feet of water on load draft, and in passing the treacherous section at the limekilns they often grounded or collided with one another, entailing great loss. It was determined, therefore, to deepen the rock-bound channel at this place to twenty feet, at the datum plane of Lake Erie established at 572.6 feet above mean tide at New York, for a least width of 300 feet. The engineers at this time disregarded the established line laid down in 1842, and held that it followed the navigable channel east of Bois Blanc Island and near the Canadian shore. This contention has long since been abandoned, however, the original boundary line being maintained to the satisfaction of the Canadian government, and saving to them the beautiful little island of Bois Blanc (Bob-Lo).

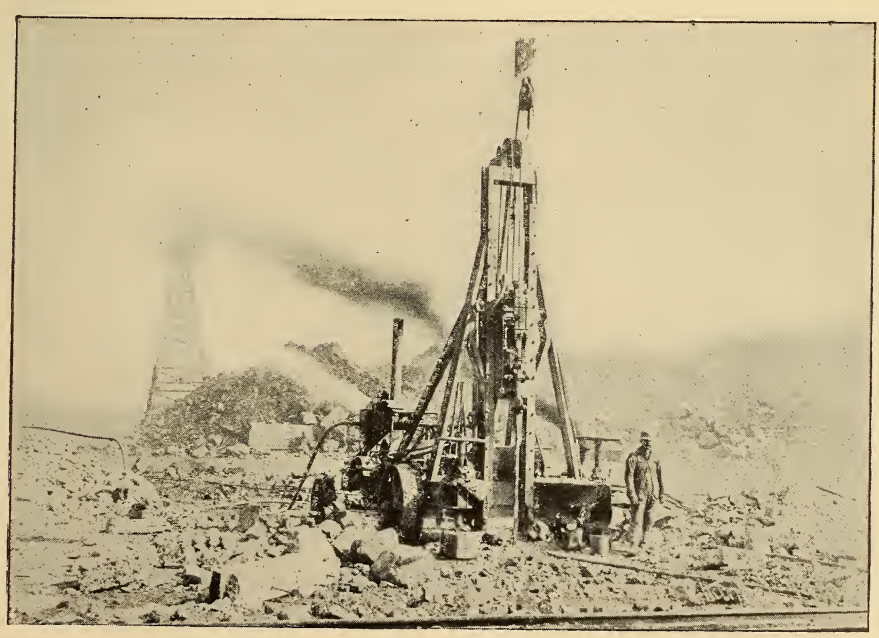
The River and Harbor Act of June 23, 1874, appropriated $25,000 "to remove bowlders and rock in Detroit River, partly in Canadian waters." Major Godfrey Weitzel was placed in charge of the work, and at once planned for accurate surveys. After

EFFECT OF HEAVY CHARGES IN BLASTING ROCK



DREDGE AND SCOW IN USE ON LIVINGSTONE CHANNEL

many delays and overcoming many difficulties he was able on Nov. 26, 1875, to submit estimates of cost. These showed $261,750 for a channel eighteen feet in depth, and $1,166,500 for twenty feet depth. Meanwhile the Canadian government, under an appropriation of $5,000, removed some of the most dangerous projecting points and other obstructions in the

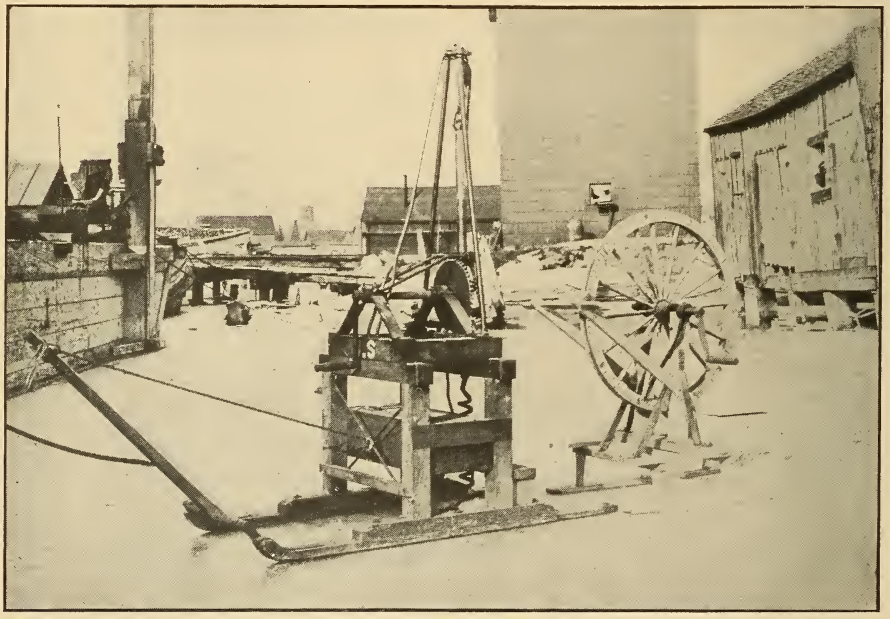


STEAM ROCK DRILL AT WORK IN LIVINGSTONE CHANNEL

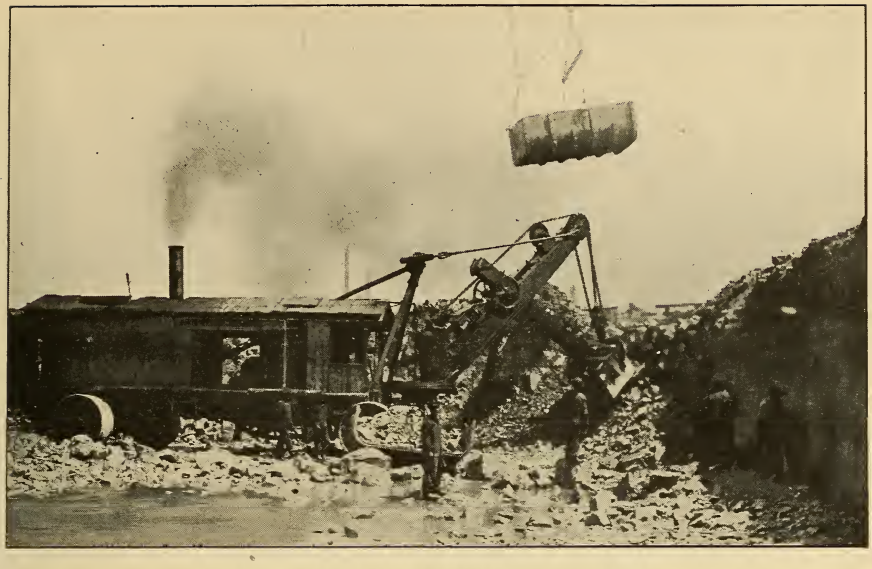
bed of the river. With the crude appliances then used, and working over an extended area, drilling holes by hand and blasting out with one-quarter pound charges of nitroglycerine, the cost was $60 per cubic yard of actual rock excavation. This cost must have been staggering to the advocates of government improvements in both countries.

It is interesting to draw a comparison between the crude and costly methods of excavation and the appliances then employed and the highly efficient plants now used for such work. In those days the work was carried on from a raft, and drilling was done entirely by manual labor. When the exact position for the raft had been determined by an instrument from the shore, the raft was raised clear of the water by means of spuds, the operations carried on, and then lowered before blasting. The deck of the raft was perforated at equal spaces and three-inch pipes inserted in the holes. Through these pipes the drills, two inches in diameter, were worked, eight being in operation at the same time. Each drill required four men to operate it, and the average depth of the holes was four and a half feet, while the charges were three and a half pounds of Oriental rifle powder. This explosive did not prove very satisfactory, however, as the rock was not broken up into small enough pieces for the dredge to handle, and nitroglycerin in three-pound charges was substituted. Later mica powder in charges of four to five and a half pounds was used, as the blast left the rock in condition to be economically handled. Mica powder was about fifty per cent. cheaper than nitroglycerin, and could be safely handled.

In striking contrast to these early methods were the highly economic means afterwards employed in excavating bed rock. By building special plants adapted to the work, Case and Jennings, of Dunkirk, were able to contract for removing solid rock at only $7.50 per cubic yard, measured in scows. Steam rock-drills, operated from huge plants on scows, drilled series of holes in the bed rock to a depth of from six to eight feet, a dynamite



CHANNEL SOUNDING APPARATUS USED IN WINTER BY UNITED STATES ENGINEERS TO DETERMINE ACCURACY OF PREVIOUS SOUNDINGS AND RESULTS OF NEW WORK



DETAIL OF SHOVEL, BUCKETS AND BLASTED DÉBRIS

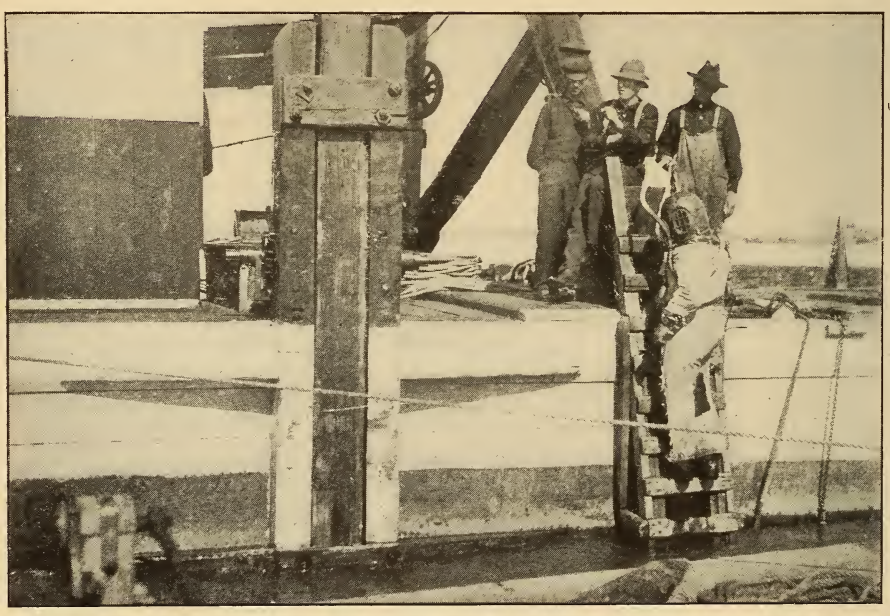
cartridge was lowered in each hole, rammed home, and set off. Powerful dredges equipped with buckets of the dipper and clam-shell type followed and removed the débris, depositing it on dump scows. These scows were then towed by tugs to the dumping ground and automatically dumped by the mere shifting of levers. Great improvements have been made in excavating machinery within the last decade, and bed rock excavation in Detroit River is now being done at varying unit prices of $1.98, $2.80 and

STEAM SHOVEL AND BUCKET "LIFTS" IN LIVINGSTONE CUT

$3.40 per cubic yard, bank measurement, according to the character of the work.

The improvement of Limekiln Crossing was continued under successive projects, the one of 1883 modifying the original plan to afford a straight channel with flaring ends on the American side. As the work progressed and the commerce of the lakes continued to increase, Congress was impressed with the magnitude of the undertaking, and $200,000 was appropriated on July 5, 1884, for continuing the operations. Under a contract with Carkin, Stickney and Cram, at a price of $5.40 per cubic yard for bed rock excavation and $1 for loose rock, the straight channel was completed on Nov. 30, 1886. But the increasing size of lake vessels and the great number passing the rock cut (about 35,000 in a season), rendered the channel with its jagged sides extremely dangerous to navigation. Widening of the channel to a clear width of 440 feet was then undertaken and completed to a depth of twenty feet on Oct. 1, 1890, at a cost of $702,122, based on a unit price of $4.43 per cubic yard.

During the last twenty years improvement work has been going on almost continuously, not only in Limekiln Crossing, but in the ranges above and below the cut. The lake levels have been gradually lowering during this period, while lake vessels have greatly increased in size and tonnage, necessitating wider and deeper channels on even a lower datum plane. The level of Lake Erie was established in 1903 at 571 feet, and all operations since have been directed to obtain a depth of twenty-two feet on that plane. The width meanwhile had been increased to 600 feet through Ballard's Reef, Limekiln Crossing, and Amherstburg Reach, and 800 thence to deep water in Lake Erie. This great work has been accomplished under various appropriations and contracts calling for immense outlay for dredging plants. The splendid results obtained will first be realized in the summer of 1912, when the final project will be completed. The total cost of the Amherstburg Channel, lying wholly in Canadian waters, amounts to $4,564,500, and has been borne entirely by the United States.



DIVER ABOUT TO DESCEND IN CLEANING-UP OPERATION, SO AS TO HAVE BOTTOM FREE OF PROJECTING ROCK OR OTHER OBSTRUCTIONS

TOWER CARRYING CABLEWAY ACROSS CHANNEL PIT

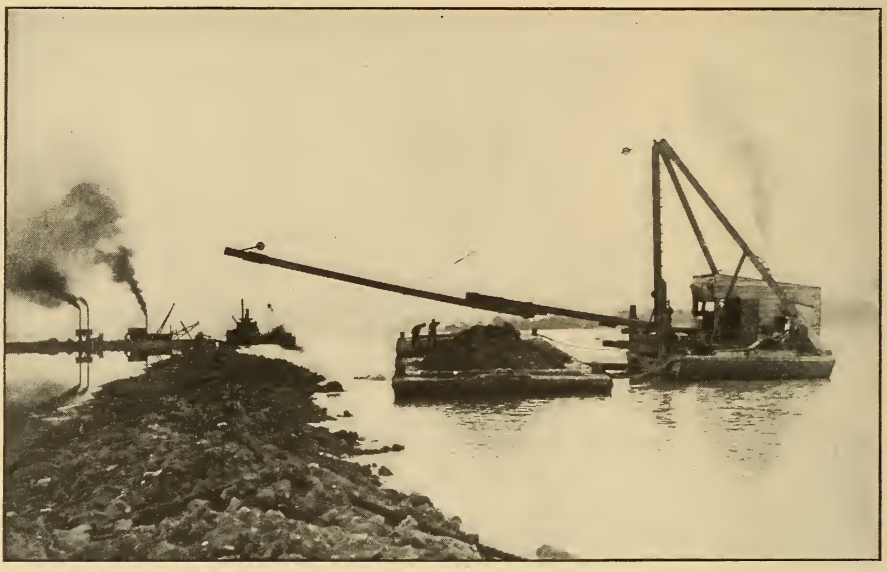
By far the greatest project which has ever been undertaken for the improvement of the Detroit River is the Livingstone Channel, which was begun in 1907 and will be open to commerce on July 1, 1912. This channel passes to the west of Bois Blanc Island (as shown by the accompanying map), and is the straightest, safest, and most convenient canal possible in that locality. It leaves the old improved channed abreast of the middle of Grosse Isle, but near the Canadian shore, and extends almost directly south in an absolutely straight line for a distance of ten miles. East and north of the Detroit River Lighthouse it joins the Amherstburg Channel, and turns off to the southeast and continues for about two miles to deep water in Lake Erie. This section of the Livingstone Channel has a mimimum width of 800 feet and a least depth of 23 feet. The whole channel lies on both sides of the

boundary line established in 1842, but a large portion of the cut is in Canadian waters.

The engineering plans provided that the clear straight channel should have a least width of 300 feet and a least depth of 22 feet at extreme low water, from Bar Point Shoals, just north of the lighthouse, to its junction at the north end with the other channel. In 1910 the plan was modified to allow for an enlargement of this section to a width of 450 feet, and a least depth of 23 feet at the established level of 571 feet. The work of widening the rock-cuts, removing the bowlders and cleaning up the bed of the channel is progressing rapidly, and will be completed in the fall of 1912.

The comprehensive plan of operations divides the stretch of river undergoing improvement into four sections, and as many separate contracts. This divisional scheme expedites the work, since the nature of the excavation differs materially and widely different plants are required for the economic handling of the spoil. There was much clay and sand removed from the channel during the first stage of the work, and many bowlders of large size were encountered. Later the excavation became almost entirely bed rock of a thickness varying from ten to fifteen feet. This was a limestone formation, and was included in the subaqueous excavation.

The most interesting and unusual features of the whole work, however, are included in the northern part of Section II and the southern part of Section I, directly opposite Stony Island. It is here that the excavation is being done in the "dry" behind a great cofferdam, which is the largest ever constructed. This huge dam is more than 13,000 feet in length and unwaters a section of the river bed 5,500 feet long and 1,200 feet wide, or an area of about 150 acres. Although of such great proportions the dam was built at relatively small cost, compared with the economies it has effected in excavation. Costing less than $40,000, including its enlargements, it has by the dry method of excavation effected a saving of about $1,800,000. This is due to the wide difference in the unit cost of subaqueous excavation by the method already described, and the unit cost of excavation in the "dry." The contract price for the underwater



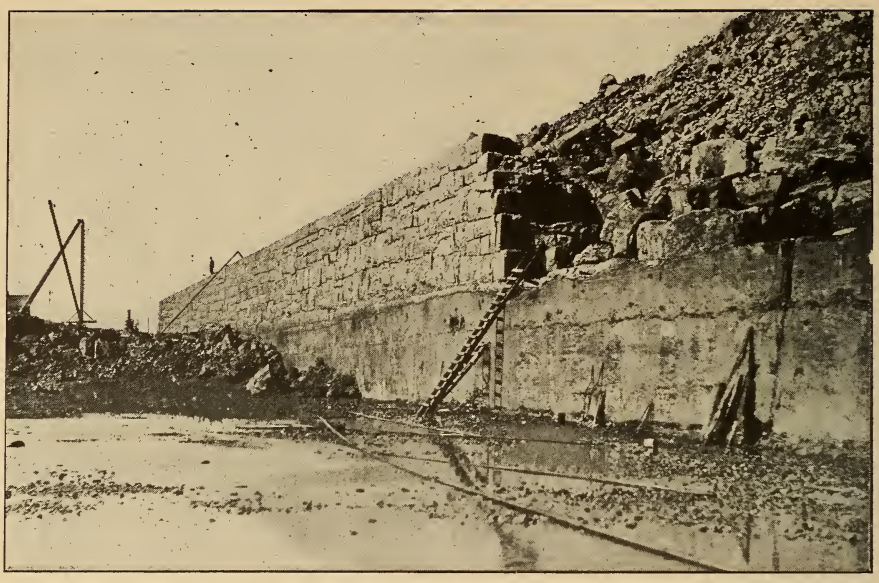
BUILDING UP THE GREAT COFFERDAM; UNLOADING SCOW BY GRAB BUCKETS

GENERAL VIEW OF LIVINGSTONE CHANNEL, LOOKING SOUTH

work outside the dam in this section is $3.40 per cubic yard, owing to the difficult character of the excavation, while the price for the work in the dry is only $1.24. The difference of $2.16 per cubic yard applied to more than 800 cubic yards of rock excavation within the dam gives the amount stated.

In building this remarkable dam no core of any kind was needed, nor was sheet piling used to render it water-tight. The material excavated from other sections of the channel was used in its construction to the extent of 218,500 cubic yards; and in the early stages of the work the dam formed a convenient dump for the scows filled with rock spill. Quantities of tough clay, stripped from the rock bed in the channel behind the dam, were dumped in to fill the cavities and interstices between the jagged mass of blasted rock. This was a cheap method of disposing

VIEW OF UPPER GALLERY AND ROCK PILE. LIVINGSTONE CHANNEL



WEST SIDE WALL, SHOWING CHANNELED POSITION IN SOLID ROCK AND RETAINING WALL BUILT ON THAT DUMP OF BLASTED ROCK BEHIND

of considerable spoil. Further deposits were made in like manner until the long rock pile filled with impervious material was built up to the surface of the river. The dam thus formed resting on solid bed rock, sloped off gradually on either side, and was topped with a deposit of clay and crushed stone three or four feet high. When the ends had been joined to convenient points on Stony Island, and the overlying clay had been excavated from the channel site, the area was unwatered.

The bed of the river having been laid bare, a comprehensive system of ditching was laid out to drain the seepage of the area into sumps at the outer corner of the dam. From these sumps the water was removed by ten- and twelve-inch pumps installed in a pumphouse close by. Meanwhile "aerial dumps" were set up. These were of the usual type with towers 100 feet high running on tracks laid on the dam on the outer side, and on the exposed rock bed of the river on the inner side. Connecting these towers and spanning the channel wire cables were stretched equipped with automatic bucket lifts operated by compressed air. At the north end of the enclosure a five-ton bucket steam shovel mounted on traction wheels, a steam channeling machine, and air rock-drills, were set up. A complete duplicate plant was installed at the south end of the open section to work toward the middle. On the island a compressor plant of one thousand horse-power and a repair shop were erected.

In operation the channeling machines, which are simply mechanically operated knives, cut away at the rock, making a smooth vertical slit, four inches wide and about twelve feet deep, to form a straight and regular face for the rock cut. The rock-drills follow close behind, placing holes crossways of the course cut by the channelers. When a series of holes has been drilled the rock is blasted out, and the steam shovel, which has a wide range of operations, picks up the débris and deposits it in large buckets. These are hoisted by the "lifts" high in the air, run along the cableways and automatically dumped in high piles at the side of the cut. As several of these buckets are in use this operation goes on continuously.

The 300-foot channel was completed in December, 1910, and the enlargement to 450 feet was begun early in 1911. So urgent is the need of the new widened channel that the contractors, Grant, Smith & Company and Locker, worked their plants with double shifts, six days a week, in winter as well as in summer, in order to complete the double-tracking of the great highway of commerce at the earliest possible time. Its completion means a saving of millions of dollars to the lakes' shipping, and will eliminate the hazard of passing vessels in the old tortuous and rocky channel. Southbound vessels heavily laden with ore, grain, lumber, and general merchandize will follow the new channel through the rock-cuts, leaving the old course to coal ships, the package freighters, and liners northward bound.

The section within the dam was completed about the middle of December, 1911, but the parts of the dam across the channel were not removed until after the ice floes from the upper lakes had passed out of the river. Then the pit had filled with water, the channel portions of the dam were removed, and the small remaining section of underlying rock ledge was blasted out and the débris cleaned up by dredges. When the channel is opened to navigation in July, vessels will steam through the rock-walled canal at full speed with ample water beneath their keels. The collisions and groundings which have been so frequent in the past will seldom occur in the future. The total cost of the Livingstone Channel was $6,805,000.

In looking down into the mammoth pit, more than a mile in length, 450 feet in width, and 60 feet deep, one marvels at the magnitude of the work and finds much in the mechanical genius of the engineers to feel a pride in their achievement. Furthermore, this work probably exceeds all records of excavation done in the same length of time on government contracts. The floor of the pit, which is solid bed rock, is almost as smooth as a new brick pavement, as laborers with chisels have worked over it and chipped off all projecting points. The wall on the outer side has a vertical face for about twenty feet from the bottom, while on the inner side the vertical wall is over thirty feet high, above which the long rock pile rises.

SETTING LINES BY TRIANGULATION. SIGNALING BY FLAG TO STAKE BOAT

The economic value of the widened and deepened channels in this great water highway is unquestioned. A striking example may be cited in the direct effect the improvements have upon shipbuilding on the lakes. With every increase in depth of water the shipbuilders turn out still larger freighters, so that for every additional foot of water afforded the cargo capacity is increased fully 2,000 tons. The latest ore ships are 616 feet in length, 62 feet beam, and 34 feet moulded depth, and will carry through the Livingstone Channel fully 20,000 tons on a draft of twenty-three feet. By their remarkable economy of operation, steaming at twelve miles an hour under a horse-power of 2,400, these great ships effect a still greater saving in a huge transportation bill.

The enormous traffic of 1910, which exceeded the combined exports and

VIEW THROUGH LIVINGSTON CHANNEL. THE COMPLETED CUT WILL HAVE A DEPTH OF 23 FEET AND A WIDTH OF 450 FEET

imports of all ocean ports of the United States, was carried in 25,578 vessel passages, with an average cargo of 3,127 tons. During the 235 days of navigation a loaded freighter passed the treacherous Limekiln Crossing every thirteen and a quarter minutes, which was a freight movement of 219 tons for every minute of every hour and day during the season of navigation. Within the last twenty-five years the average freight charges per ton-mile have been reduced from 2.3 mills to .78 of a mill (the record of 1910). The difference, which is a direct saving, is 1.52 mills for every ton carried each mile through the highway of the Great Lakes. Based on 80,000,000 tons, the commerce of 1910, the saving amounted to $121,600 for every mile, and, since the average freight haul was 810 miles, the economic value of the present deep channels was $98,496,000 for the year 1910 alone. It was well worth while spending $11,369,500 in thirty-seven years for the improvement of the Detroit River channels in order to save nearly $100,000,000 every year to the commerce of America.

MODERN TESTING MACHINES

PART II. VARIOUS SHEAR TESTING MACHINES.

By C. A. M. Smith, M. Sc.

In the issue of this magazine for February of the present year, Professor Smith examined the various methods and appliances for testing the resistance of materials of construction to tension, compression, and bending. The present paper forms a continuation of that discussion and takes up the determination of shearing stresses, both when occurring in torsion and when considered directly. This will be followed by a paper devoted to the many ingenious instruments for measuring strains.—THE EDITOR.

THE investigation of the behaviour of materials when subjected to torsion is of equally important consideration as to their ability to withstand compression and tension. In the last article,* machines were described for testing under the latter conditions. It is the purpose of this present article to consider machines for determining the strength of materials to resist twisting.

When a bar is fixed at one end and a couple is applied at the other end in a plane at right angles to the axis of the bar, it undergoes a deformation, termed torsion, which produces simple shearing stresses. The general condition of stress produced in a bar under such loading is that there are shear stresses of equal intensity on transverse and radial longitudinal sections—*i. e.,* at right angles. Equilibrium is maintained by the production of tensile and compressive stresses along helices drawn on concentric cylindrical sections at an inclination of 45 degrees to the axis. The behaviour of a material subjected to torsional loading depends upon whether it is brittle or ductile. With a brittle material like cast iron, fracture occurs at an angle of approximately 45 degrees to the axis and forms a complete revolution of the bar. The explanation is, that cast iron is weaker in tension than in compression or shear, so that finally failure takes place along that surface where the stress is tensile. With ductile materials, the specimen twists considerably, and fracture finally takes place by shear along a plane approximately perpendicular to the axis of the specimen. Mixed steel and wrought iron exhibit these peculiarities. Tests on cast steel show that its behaviour is intermediate between that of cast iron and the ductile materials, according as the steel is hard or soft.

THE BAILEY TORSION MACHINE

A diagrammatic sketch of the Bailey machine is shown in Fig. 1. The specimens are prepared in the form of cylindrical bars with enlarged ends, generally of square section, which fit into square caps, constituting the grips. Since the object of the test is to find the resistance of the bar to torsion, it is not necessary to grip the bar tightly in the clips, but only to prevent it from rotating in them. This fact is utilized in the measuring apparatus for determining the applied torque. Referring to the diagram, the end A_1 of the bar is twisted by means of the handwheel B, which turns the wormwheel C. This, in turn, rotates the spur-wheel D, to which the grip A_1 is rigidly attached. The other end of the bar, held in the clip A_2, attempts to turn with A_1, and with that intent pulls at the lever E, which is connected by the tie-rod G to the mercury diaphragm F. The pressure on the diaphragm causes the mercury to rise in a column H, which balances the pressure due to the tie-rod G. Thus the height of the column H gives a measure of the torque load applied. The actual torque to which the speci-

* See CASSIER'S MAGAZINE, February, 1912.

men is subjected is obtained by multiplying the torque load by the perpendicular distance between the axis of the rod *G* and the axis of the specimen. The grip A_2 rotates just a little, the movement being just sufficient to produce a pull in the tie-bar *G*, which is recorded by the mercury column.

THE THURSTON TORSION MACHINE

In this machine the load is applied in the same way as the preceding, but the method of measurement is different. A pendulum weight is affixed to the free end of the test bar, and, as the load is applied, the test bar is able to move this pendulum through a distance proportional to the load. The pendulum therefore is caused to move a pointer along its quadrant, the latter being calibrated to read the load on the specimen. When the bar breaks, the pendulum swings back into a vertical position, but the pointer remains in the position that it had assumed just before the specimen broke. The final position of the pointer then gives us the breaking torque on the test bar.

THE AVERY TORSION MACHINE

The Avery machine (Fig. 2) also has its load applied in the same manner as the Bailey and Thurston machines, viz.: by a worm and worm-wheel, but again the method of measurement is different. The stress is indicated by means of a system of weighing levers similar to those in the Riehlé testing machine, being finally measured by running out a poise along a graduated steelyard. In the 15,000 inch-pound machine there are three of these poises, each weighing 60 pounds. The first indicates up to 5,000 inch-pounds, when each scale division on the steelyard represents ½ pound. When two poises are coupled together, readings can be taken up to 10,000 inch-pounds and when the whole 180 pounds are run along the scale they give a total capacity of 15,000 inch-pounds with readings of 5 inch-pounds per scale division. A vertical scale is sometimes fixed on the front end of the steelyard and a telescope to the frame of the machine. By this means we can adjust the lever with great accuracy until it rests in a perfectly horizontal position. This machine will take square bars up to ⅞ inch side, or rectangular specimens up to a maximum of 1 inch by ¾ inch. The bracket on which the straining gear is fixed is capable of movement to admit specimens of a maximum length of 15 inches. The shortening of the specimen under the torsional load is provided for by the insertion of hardened steel rollers. The actual strain on the specimen is observed by fastening indicating arms to its two

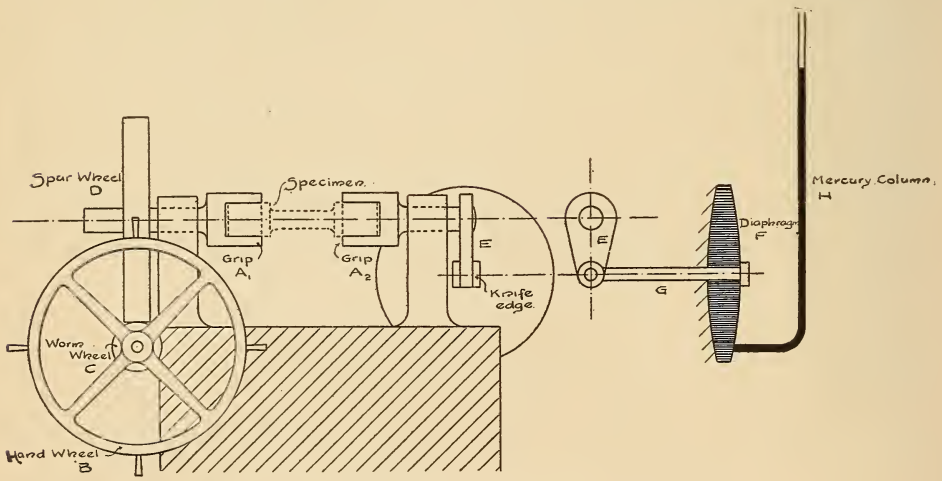


FIG. 1.—DIAGRAMMATIC VIEW OF BAILEY TORSION TESTING MACHINE

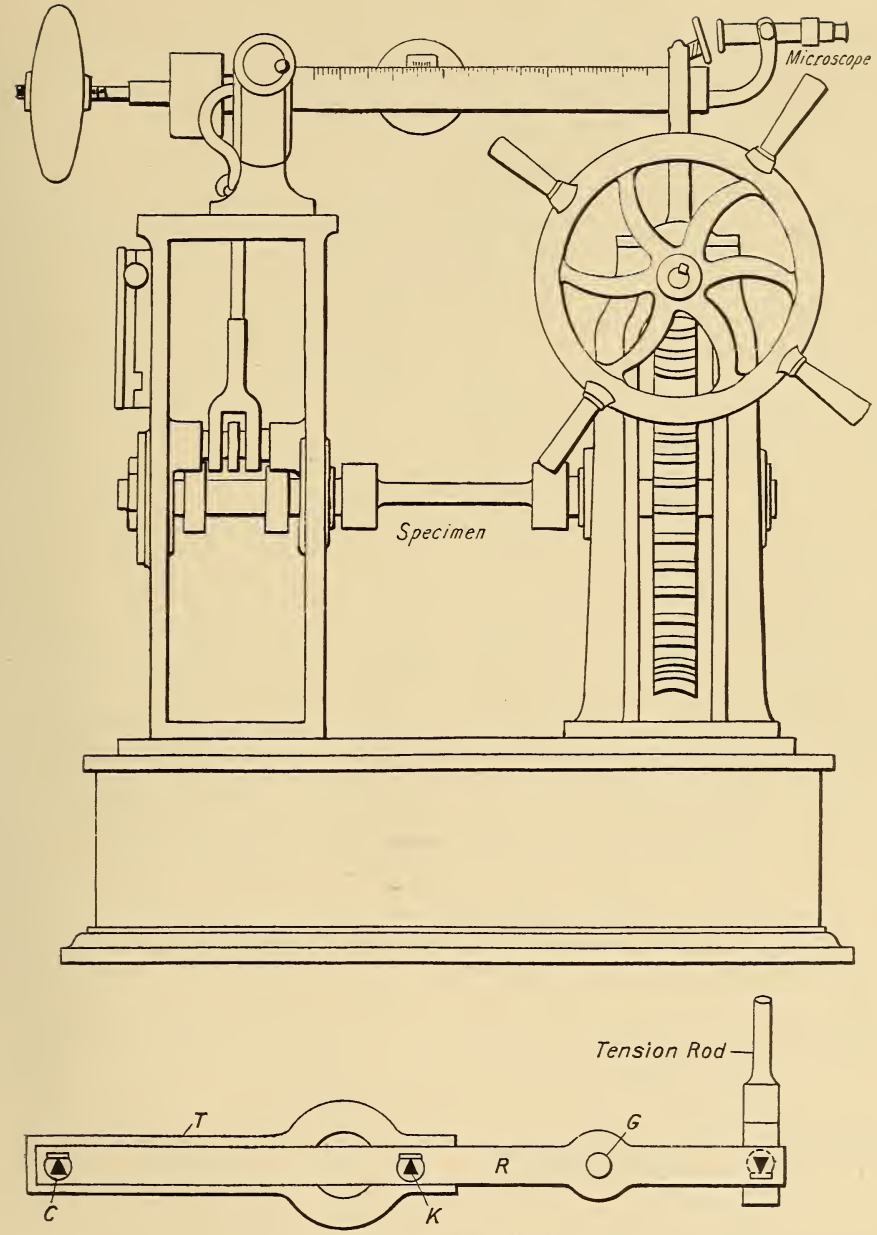


FIG. 2.—THE AVERY TORSION TESTING MACHINE

ends, a gauge length apart. These arms are in line with each other at the start, but as the load is applied one end gets twisted more than the other, so that the angle between them at a definite load gives us the torsional strain at that load. This machine is also arranged to measure torsional stress applied in the reverse direction. The main torsion lever *T* is keyed on a sleeve which is free to revolve in ball bearings. An intermediate lever *R* is arranged within this main lever, and is pivoted at a point *G*, between the axis of the specimen and that of the tension rod which transmits the

stress to the steelyard. When the torsion is applied in a clockwise, the knife edge *C* of the main lever pulls up the left-hand end of the intermediate lever and so depresses the end that is attached to the tension rod. When the stress is applied in a counter clockwise direction the knife edge *K* raises the point *E* of the intermediate lever and again pulls the tension rod downwards. So that in whatever direction the torsional load is exerted the short end of the steelyard is always pulled downward, balance being restored by running the poise along the arm. The leverages are so arranged that the load on the specimen in either direction can be read directly on the same scale. The same makers also manufacture a testing machine to give results in tension and torsion simultaneously, so that the effect of the combined stresses can be read off in one machine. It consists practically of a hydraulic tension machine and a hand power torsion machine on the same bedplate. The principles upon which the combined machines act are similar to those already given for the separate machines. The two steelyards, one for each kind of stress, are placed so that neither interferes with the working of the other, but are near enough together to enable the readings to be taken by one man.

RIVET TESTS

Direct shear or "rivet" tests, that is to say, shear tests as distinct from torsion tests, are not very frequently carried out, owing to the difficulty of insuring pure shear without bending. When such experiments are made they are generally performed in an ordinary machine arranged for tension or compression such as has been described in the previous article. Under such conditions use is made of special shackles, of which there are many forms, that will readily suggest themselves as modifications of the single example given. The shackles shown in Fig. 3 consist of two rectangular blocks *A* and *B*, which are bolted together by the four bolts *C D E F*. Down the centre of these blocks is cut a rectangular channel *G* in which a rectangular piece *H* is allowed to slide. The three discs *K L* and *M* fit accurately in a hole which is bored through *A* and *B*, and are fixed in position by the hollow nuts *N* and *O*. The specimen is

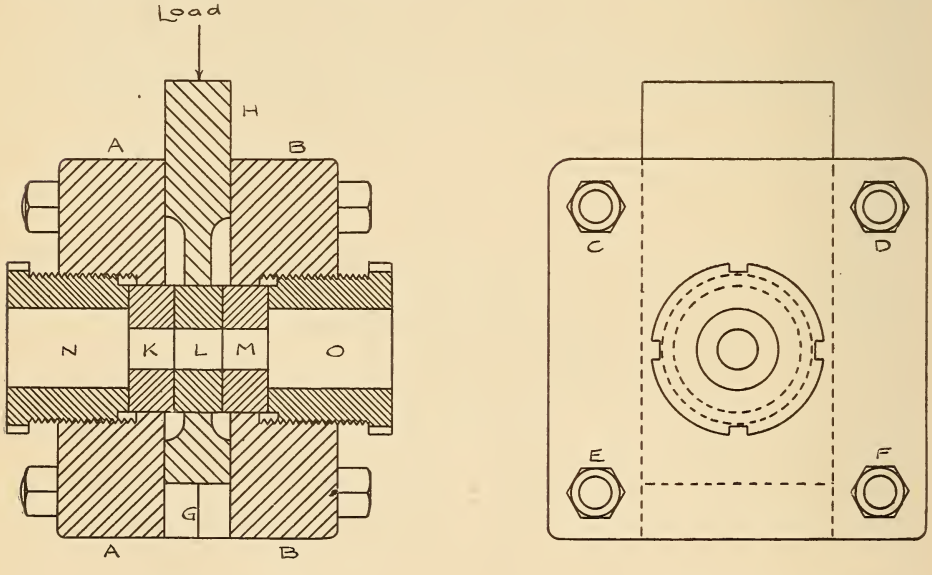


FIG. 3.—APPARATUS FOR DIRECT SHEARING TESTS

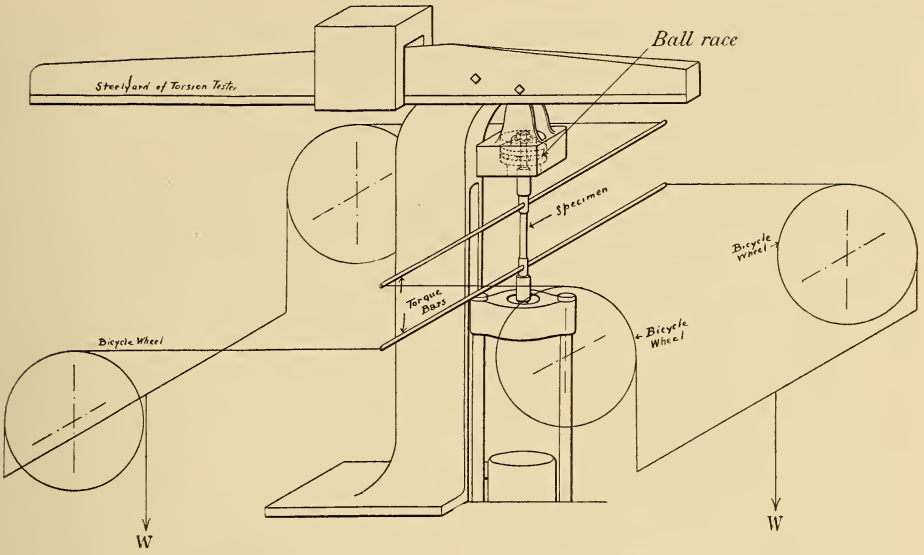


FIG. 4.—APPARATUS FOR COMBINED STRESSES

supplied in the form of a cylindrical bar which accurately fits inside the holes in *K L* and *M*. When the bar is in position the load is applied to *H*, and the specimen is sheared off at the joints between *K* and *L*, and *L* and *M*, the strength in double shear thus being ascertained. It is important that the faces of *K*, *L*, and *M* should be perfectly true, as if there is any space between them the material is not in pure shear, but partly in bending. With this apparatus tests on materials can be carried out in either single or double shear. The bearing surface should always be kept as large as possible, so that when making tests in single shear the specimen should be pushed so far through the middle die that it just misses fouling the end die. To avoid errors due to bending the specimen should be a very good fit in the dies, and for the same reason there should be no clearance between the latter when in position. It is probable that, with such tests, a pure shear is never obtained because of the complication due to bending. The most satisfactory method of obtaining pure shear is that of using a hollow specimen for a torsion test. At the same time the results obtained from the "rivet shear" tests are valuable, as they are obtained under conditions such as take place in practice.

COMBINED STRESS TESTS

Machines have been built for applying, simultaneously, a bending or tension stress and a torsion stress. Such machines are generally complicated. A modification of the ordinary testing machine is shown in Fig. 4 whereby it is possible to make combined stress tests. A ball race must be fitted at each portion of the testing machine which carries the grips for the tension specimen. The torque is applied by bars to the ends of which are attached cords passing over bicycle wheels. The latter provides pulleys which are practically frictionless, as ball bearings are used. The load is applied by adding weights to a box.

THE STORAGE OF COAL AND SPONTANEOUS COMBUSTION

By Horace C. Porter

PAPER PRESENTED BEFORE THE PITTSBURG SECTION, AMERICAN CHEMICAL SOCIETY

FUEL, as a factor in the daily life of the individual, has greater importance than is often realized by the casual thinker. In 1910 the United States produced and consumed about 5¼ tons of coal per individual of population, and the total fuel costs of the country, for manufactures, transportation, heat and light, etc., averaged nearly $20 per year per individual, or $100 for each family. Power, heat and light—the foundation on which industries and the maintenance of homes rest—are produced directly from fuel. The railways of the United States used on their locomotives in 1906, 90,000,000 tons of coal, or one-fifth of the country's entire coal production; in other words, each family paid $20 a year to keep the railroads alone supplied with coal.

Methods of handling and of stocking a raw material so nearly universally indispensable as is fuel assume importance when the consumption at any one point is large and when conditions demand a large surplus stock. The producer of coal is often required to ship his product long distances by land or by water and to store large quantities at a distributing point. The possibility of strikes at the mines or on the railroads, of car shortages, and of delays due to weather conditions, frequently make it advisable, and, in fact, a common practice, for as much as 500,000 tons of coal to be stored at one point, for a period of three months to a year or longer.

At Montreal and vicinity and in Nova Scotia 250,000 to 500,000 tons in one pile are sometimes in storage, owing to difficulties of transportation in the winter season; at Duluth and Superior and other distributing points on the Great Lakes one-half million tons is a common amount in stock at one point; by-product coke and gas companies in the Chicago district have on hand open-air coal piles of 300,000 to 500,000 tons each during the fall and winter season; the Western Electric Company, at Hawthorne, Ill., near Chicago, in an effort to improve their coal storage equipment installed in 1907 a submergence storage plant for 10,000 tons; on the Isthmus of Panama, the Panama Railroad Company maintains a large open-air stock pile as a safeguard against delays in delivery of cargoes from the United States; many of the navy yards and naval coaling stations remote from sources of supply, as at Key West, Fla., Southern California points, Hawaii, Samoa and the Philippines, may keep as much as 50,000 tons in stock for protracted periods. There will, very likely, be coaling stations on the Isthmus of Panama after the completion of the canal, which, on account of the large demand and the distance from the source of supply, will need to be of large capacity.

If it is true that coal stored in such quantities for long periods deteriorates in quality, it is important to determine whether the percentage loss of value is great enough to make the aggregate loss in a large stock a serious matter. Does the loss in heat units, in, say, 10,000 tons, during one year's exposure, mean a money loss sufficient to justify the cost of underwater storage or other protective

equipment? The Western Electric Company, at Chicago, from preliminary experiments, concluded that such cost was justified in case of Illinois coal, and in 1907 installed, as here mentioned, a 10,000-ton under-water storage plant of concrete construction. After two years' storage they found that their submerged coal had a heating value about 2 per cent. greater than that of a similar coal which had weathered two years. This small difference hardly justifies the cost (about $70,000 for construction and 7 cents per ton for handling), but the avoidance of all risk of spontaneous fires in the stock may be considered to have been in itself sufficient justification.

A few other instances are known of commercial trials in the United States of submerged storage—e. g., one of 12,000 tons at Minneapolis, Minn.; but the practice has not become by any means general.

The Bureau of Mines, largely at the instance of the Navy Department, took up the storage problem in the summer of 1909. Experiments were begun to determine the loss of heating value undergone during storage by the actual coal substance independently of moisture changes and of inequalities in ash, which, of course, in themselves affect the heating value. The losses suffered by coal in storage may be due to two causes: (1) weathering at ordinary temperatures, and (2) spontaneous heating, with consequent burning of the coal and distillation of gases. The former has been held by many authorities to be a serious factor, losses of 10 to 50 per cent., due to weathering alone, having been claimed in various reports of experiences. There is little doubt now, however, that this first factor is a minor one as compared to the serious danger from the second cause—viz., spontaneous heating. A study has been undertaken by the Bureau of both factors with a view to determining the extent of the loss and contributing to an explanation of the nature of the phenomena.

First, for determination of the amount of deterioration by weathering, four coals, representing distinct types, were placed in storage and carefully sampled at regular intervals. New River coal from the Sun mine, Fayette County, West Virginia (a smokeless coal, about 20 per cent. volatile matter, largely used by the Navy Department), was stored in small lots—50-pound portions, ¼-inch coal, in boxes submerged under sea-water, and 300-pound portions, both ¼-inch and run-of-mine, exposed to the air. All of these small lots, thirty-five to forty in number, were made up out of one large lot, well mixed. Pocahontas coal, a type similar to the New River, was stored in a 120-ton pile in the open air on the Isthmus of Panama. Pittsburg gas coal, in order to study its deterioration in gas-making qualities in co-operation with the University of Michigan, was stored in 5-ton outdoor open bins at Ann Arbor, Mich. Sheridan, Wyoming, sub-bituminous coal, or black lignite, was stored at Sheridan in outdoor bins that held 3 to 6 tons each. Duplicate samples were taken from each lot at each sampling, and an endeavor was made to obtain as nearly as possible a representative sample of the entire lot, both of the weathered and unweathered portions. Some variation in ash and sulphur was unavoidable in duplicate samples, but the effect of these variables is eliminated in calculating heat values to the basis of actual coal substance. Small lots and a comparatively fine state of division were conditions purposely adopted with the New River coal in order to make the tests of maximum severity.

A summary of the results obtained thus far is given in Table I. The values given are averages of at least two duplicate samples, which showed a variation in most instances of not more than 30 calories (54 B. t. u). With New River coal in two years the largest loss was 1.8 per cent., this being at Key West, Fla., and in one year 0.9 per cent. at the same place.

TABLE I.—DETERIORATION OF COAL.

Calorific values (in gram calories) of the coal substance, moisture-ash-sulphur-free coal before and after storage.

Kind of Coal.	Storage Conditions.	Place.	Calorific Values. As Stored.	After 3 Months.	After 1 Year.	After 2 Years.	Per Cent Loss. In 1 Year.	In 2 Years.
New River, W. Va. (a)	¼" coal under sea water.	Portsmouth, N. H.	8,761 8,763	.....	8,759	8,730	0.00	(g)0.39
	"	Norfolk, Va.....	8,754 8,772	.....	8,763	8,737	0.00	(g)0.40
	"	Key West, Fla.....	8,747	.....	8,732	8,770	0.18	0.00
	¼" coal under fresh water.	Pittsburgh, Pa.....	8,752	8,762	8,749	8,760	0.00	0.00
	¼" coal exposed to air indoors.	Portsmouth, N. H.	8,779	8,738	8,742	8,709	0.42	0.80
	"	Norfolk, Va.....	8,751	8,742	8,736	8,717	0.18	0.39
	"	Key West, Fla.....	8,754	8,728	8,676	.....	0.90	....
	"	Pittsburgh, Pa.....	8,769	8,736	8,719	8,720	0.57	0.56
	R. O. M. coal exposed to air indoors.	Portsmouth, N. H.	8,754	8,758	8,748	8,734	0.00	0.23
	"	Norfolk, Va.....	8,743	8,764	8,725	8,725	0.21	0.21
	"	Key West, Fla.....	8,745	8,733	8,710	.....	0.40	....
	"	Pittsburgh, Pa.....	8,753	8,758	8,740	8,743	0.16	0.11
	¼" coal exposed to air outdoors, uncovered.	Portsmouth, N. H.	8,741	8,730	8,701	8,674	0.46	0.77
	"	Norfolk, Va.....	8,726	8,709	8,666	8,625	0.69	1.16
	"	Key West, Fla.....	8,739	8,721	8,680	8,592	0.68	1.85
	"	Pittsburgh, Pa.....	8,763	8,726	8,700	8,665	0.72	1.12
	R. O. M. coal exposed to air outdoors, uncovered.	Portsmouth, N. H.	8,775	8,766	8,760	8,722	0.18	0.60
	"	Norfolk, Va.....	8,743	8,745	8,720	8,695	0.27	0.55
	"	Key West, Fla.....	8,752	8,708	8,722	8,632	0.34	1.29
	"	Pittsburgh, Pa.....	8,752	8,740	8,716	8,696	0.41	0.64
Pocahontas, Va.	120-ton pile, R. O. M. coal outdoors.	Panama.....	8,794	8,787	8,762	.....	0.36	....
Pittsburgh bed.	4 tons R. O. M. coal, in open bin, outdoors.	Ann Arbor, Mich...	8,541	(b)8,539	8,526	.....	0.18	....
			8,541	(c)8,553	8,528	.....	0.16	0.00
Sheridan, Wyo. (e) Sub-bituminous.	R. O. M. open bin 5 feet deep.	Sheridan, Wyo....	7,370	7,174	.....	(f)7,135	....	(d)3.19
	R. O. M. closed bin 5 feet deep.		7,370	7,202	.....	(f)7,094	....	(d)3.75
	R. O. M. closed bin 15 ft. deep.		7,370	7,303	.....	(f)6,982	....	(d)5.26
	Slack, closed bin 15 ft. deep.		7,355	7,166	.....	(f)6,990	....	(d)4.96

(a) Heat value of representative mine sample of this coal, moisture-ash-surphur-free, 8,768 cal.
(b) After six months' storage, entire lot in bin.
(c) After six months' storage, upper 6 inches at surface of bin.
(d) Per cent loss in two years and three quarters
(e) Each bin contained 5 to 10 tons.
(f) After two years and three quarters.
(g) On the basis of the original value of the same test portion (not that which was sampled at one year).

There was practically no loss in under-water storage. Pocahontas coal at Panama lost 0.4 per cent., and the Pittsburg gas coal at Ann Arbor practically nothing in one year's weathering. The Wyoming coal in one of the bins lost 2½ per cent. in the first three months and over 5 per cent. in two and three-quarter years. It had slacked badly on the surface, but this did not penetrate more than 12-18 inches.

With New River and Pocahontas there was no apparent slacking of lumps or physical deterioration in the run-of-mine, although no actual measurements of such a change were made. In all cases the ¼-inch crushed coal exposed to the weather deteriorated in heat value more than the run-of-mine, and deterioration was greater in warm climates.

These results, while they cover only a few coals, appear to show that the effect of weathering on the heating value of Appalachian coals is small, not more than 2 per cent. in two years, and that the effect has been by many authorities greatly over-estimated. In this connection it is of interest also to note a few reports of other tests which seem to corroborate in some degree the results of the tests just described. An analysis was made recently of Pocahontas coal sampled by the Navy Department from a stock which had been kept under cover for 4 years at Sitka, Alaska. The calorific value of the moisture, ash and sulphur free coal substance was 8,730 calories as compared to an average on fresh Pocahontas coal of 8,792 calories, showing a loss in 4 years of about 0.7 per cent. The coal recovered recently from the old Battleship *Maine,* sunk in Havana harbor

for 14 years, has been analyzed by the bureau and found to have a heating value on the moisture, ash and sulphur free basis of 8,588 calories. Although the identity of this coal has not been fully established, there are good grounds for supposing that it came from a mine in the New River district, West Virginia. On this assumption, there has been a deterioration during its 14 years' submergence of about 160 calories, or 1.9 per cent. A report of tests made by the Chicago, Burlington & Quincy Railroad Company at Alliance, Nebraska, on about 6,000 tons of coal from Cambria, Wyoming, stored in an open pile for 4 years, shows a loss of 6.4 per cent. in heating value on the moisture, ash, sulphur free basis in samples taken 4 to 8 feet below the surface.

When spontaneous combustion occurs in a coal stock the loss of value becomes much greater and is indeed a very serious matter. Even though actual fire, with incandescence and flame, does not occur, the loss by oxidation, if the coal is heated, is a serious one, since the rate of oxidation of coal increases very rapidly as its temperature rises; and furthermore, at moderately elevated temperature changes begin to take place in the composition of the coal substance which affect its coking quality and its yield of gas and by-products. When once a fire has well started in the under portions of a large coal pile or bunker, it is almost impossible to extinguish it by the ordinary means. Water or steam will not penetrate through the coked arch formed over the hot pocket, and the only effective recourse is removal of the heated portions.

A by-product coke plant in the Middle West reports that its 100,000-ton stock pile of smokeless coal (which is renewed every summer) is on fire from spontaneous heating for at least three months of every year. A large power plant in New York reports that one or two out of its 20 odd coal bunkers (2,000 to 3,000 tons capacity each) are always either on fire or badly heated. Spontaneous fires in ships' cargoes of coal were, 30 years ago, very common, particularly on English vessels. It is recorded that in the 9 years from 1873 to 1882, 57 boats sailing from British ports were lost through spontaneous combustion of their coal cargoes. The Bureau recently investigated a troublesome bunker fire on a Panama steamer sailing between New York and Panama, the fire undoubtedly having started from spontaneous combustion in some old coal, left on board during several trips and lying near the boilers next to a hot bulkhead.

A circular letter was sent in January, 1911, to more than 2,000 large coal consumers throughout the country in order to gather statistical information on cases of spontaneous fires in coal. The results of this inquiry are tabulated below:

REPLIES TO LETTERS OF INQUIRY ON SPONTANEOUS COMBUSTION

Total number of replies received	1,192
Replies from Eastern section of United States	762
Replies from Central and Western sections	369
Replies reporting cases of spontaneous combustion	260
Cases reported which named the coal	220
Cases reported in "smokeless" coals (Appalachian)	95
Cases reported in other Appalachian coals	70
Cases reported in Interior and Western coals	55
Per cent. of cases in the total replies received	21.8%
Per cent of cases in the Eastern replies received	25.3%
Per cent. of cases in the Western replies received	18.1%

The results of the inquiry point to the Appalachian coals as furnishing a majority of the total cases reported even when compared on the basis of the respective percentages of cases in the replies from each section of the country. The results also show that the "smokeless," low volatile Appalachian coals have been found at least no less dangerous for storing than other types. Probably these results have been influenced by the fact that Appalachian coals, particularly the smokeless variety, are more frequently stored than are the Western coals. These latter coals are more

generally feared by consumers in respect to storing large quantities from the fact that they are known to lack in storage qualities, and are subject to spontaneous heating.

Spontaneous combustion no doubt results from an accumulation in a combustible material of the heat of its oxidation, or occasionally the heat of other chemical reactions, of fermentation, or of bacterial action. It is a fact that coal oxidizes at the ordinary temperatures of the air and develops heat thereby. Since coal is a very poor conductor of heat and its specific heat also is low, its temperature may rise rapidly in pockets where the transfer of heat by convection currents of air is restricted. As showing the poor heat conductivity of coal, instances are known of snow remaining unmelted beneath a coal pile during the entire summer. Cape Breton coal stored in Nova Scotia during the summer has been found after shipment to Montreal to contain Cape Breton snow of the previous winter. Temperature measurements in a coal pile often show ordinary air temperature in one spot and an actual fire in another not 3 feet away.

In studying the question two phases present themselves: (1) What is the primary source of the heat and how can the reactions causing the heat best be reduced in intensity or eliminated? (2) How can the physical conditions of storage best be regulated so as to permit dissipation of the heat?

In answer to the first question, the fact may be cited first that coal standing in closed bottles at ordinary temperature rapidly takes up the oxygen of the air. An air current passed slowly over a sample of coal in a warmed tube loses oxygen to the coal in amounts rapidly increasing with rise of temperature, and the temperature of the coal also rises above that of its surroundings. If the conditions are exaggerated by passing 50 per cent. oxygen and by heating the coal to 140 degrees C., some coals easily ignite under the influence of the air current. Different coals show different temperature rises under the same conditions and the rise does not appear to be parallel to the sulphur content. These experiments clearly bring out the fact of the absorption of oxygen by coal at ordinary temperatures either by the carbonaceous material of the coal substance or by its mineral impurities, such as sulphides of iron; also the fact of the development of heat by such oxidation. The comparative rates of heat development by oxidation in coal substance proper and in iron pyrites remain to be settled before judgment can be passed on the disputed question of the importance of pyrites in spontaneous combustion. Pyrites, and particularly its near neighbour, of the same composition, marcasite, without question oxidize by weathering and thereby develop heat. Moisture is necessary to the reaction. Though the amount of pyrites present may be small, it may nevertheless act as a kindler, giving a little initial heating which will start rapid oxidation in the coal. On the other hand, if its rate of oxidation in moist condition can be shown to be slower than that of coal substance itself, there can hardly be adequate reason to consider it a dangerous element in the initial heating.

In a laboratory test in which 50 per cent. oxygen was passed over coal heated to 140 degrees and 162 degrees C. it was shown clearly that some kinds of coal undergo oxidation more rapidly than others. But unfortunately for the value of our test, many of the coals which show little or no heat development in this test prove in practice to be dangerous coals to store. We are led, therefore, to a consideration of factors other than ease of oxidation, e. g., the effect of physical conditions of storage on the accumulation or dissipation of heat—the second important factor mentioned above as concerned in the problem.

As the oxidizing action on coal is, in its beginning, largely a surface action, the amount of surface exposed

or the fineness of the coal and the amount of dust present will have large influence on the intensity of the action. A committee of the American Railway Maintenance of Way Association reported that in its opinion the presence of dust in a coal stock was the prime cause of spontaneous combustion. Many other authorities have expressed similar warnings. An instructive instance from commercial practice is furnished by the Calumet & Hecla Mining Company. At the Tamarack coal dock near Houghton, Michigan, a stock of 100,000 tons of Pittsburg run-of-mine coal was continually giving trouble with spontaneous fires until a year or so ago. At that time the plant was improved and enlarged to double its capacity, and a provision was made for screening the coal before storing. On elevating from the boats, the coal passes over screens which discharge the fines onto railway cars for immediate use, the lump being sent to the stock pile. Practically no trouble with fires has been encountered since the new system was installed.

Friability in coal is thus a factor in promoting spontaneous heating. Run-of-mine coal is often subjected to 10 to 15 drops during the course of its handling between mining and placing in stock; and when received by the consumer it often contains 90 per cent. or more of material that will pass a 1-inch screen. The following results of comparative breakage tests by the 6-foot drop method show this variation between coals in friability and show also the comparatively large friability number in the low volatile, smokeless type:

Other important factors affect the dissipation of heat in a coal pile. Facility of air passage through the material influences in large measure the accumulation of heat. If the amount of air which can penetrate to a warm spot in the interior is sufficient to produce heat at a faster rate than it can be carried away in the same air current, the result will be a rise in temperature. If air penetrates very slowly, as it does in fine slack coal, the rate of combustion is very slow and very little heat is developed. If air penetrates very abundantly when the coal has not yet become much heated the coal is cooled by the convection currents of air.

Some studies of spontaneous fires in a large coal pile at a commercial plant in the Central West have well illustrated these points. Temperatures were taken at different depths in the pile and samples of air withdrawn at the same time. Where the coal was warm, the oxygen percentage in the air was found to be re-

TABLE II.—BREAKAGE TESTS OF COAL.

50 pounds lump coal, over 2-inch screen, dropped 6 feet on an iron floor, 4 times without intermediate screenings.

Coal No.	Description.	Percentage Passing 2-Inch.	½-Inch.	⅛-Inch.	Loss in Test, Per Cent.	Remarks.
197	Pocahontas, W. Va.....	56.3	25.6	11.9	0.0	McDowell Co., W. Va.
198	Pocahontas, W. Va.....	51.8	23.8	10.1	.3	McDowell Co., W. Va.
198	Pocahontas, W. Va.....	54.0	24.8	11.6	0.0	McDowell Co., W. Va.
254	Pittsburgh bed.....	47.1	13.1	4.4	.6	Greensburg, Pa.
254	Pittsburgh bed.....	45.5	14.4	4.8	.5	Greensburg, Pa.
254	Pittsburgh bed.....	46.5	14.3	4.3	.4	Greensburg, Pa.
208	Clearfield Co., Pa.....	70.3	30.8	13.1	.8	Imperial (and other mines).
102	Fire Creek seam.....	70.1	26.7	11.3	.3	Fayette Co., W. Va.
290	Battleship Maine.....	69.6	22.2	8.4	.3	Submerged 14 years.
...	Blockton, Ala.....	48.3	11.6	3.7	0.0	
105	Carterville, Ill.....	44.6	11.0	3.4	0.0	Williamson Co.
205	Dawson, New Mexico.....	47.5	10.5	3.3	.1	
205	Dawson, New Mexico.....	44.8	10.1	3.0	.1	
279	Kemmerer, Wyo.....	54.3	10.5	3.3	0.0	
279	Kemmerer, Wyo.....	55.1	11.1	3.4	0.0	
202	Eagle Pass, Texas.....	53.8	10.8	2.8	.3	
202	Eagle Pass, Texas.....	55.0	10.9	2.6	.4	
203	Chimney Rock, Mont.....	46.4	14.5	2.5	0.0	
203	Chimney Rock, Mont.....	43.3	12.3	3.9	.3	
272	East Creek, Wash.....	42.5	8.4	2.5	.4	
272	East Creek, Wash.....	43.3	8.0	2.4	0.0	
92	Black Diamond, Wash.....	74.9	25.5	5.6	.3	
277	Carneyville, Wyo.....	43.8	9.0	2.4	0.0	Sheridan District.
277	Carneyville, Wyo.....	44.9	10.8	2.8	.3	Sheridan District.

duced considerably below normal and CO_2 was found, although not in quantities proportionate to the oxygen absorbed. In some places the oxygen was very low, although the temperature was still much below the danger point, this condition being due to restricted air circulation. At only 9 feet below the surface at one of these points the air was almost entirely exhausted of oxygen. A pocket of fire discovered at 23 feet depth at another point proved an interesting instance of high heating in one small spot. At this point there was a free draft of air from below the fire, as shown by the normal percentage of oxygen just below the pocket. The conditions here were probably such as have been described above as favourable to continuous heat development, viz., the free access of sufficient air to support the combustion and of air warmed somewhat by passing through a 20-foot section or more of the coal.

It is often noticed that after a heavy rain or alternate wetting and drying an open coal pile becomes heated spontaneously. This is possibly due to the washing of dust and fines down into a compact layer 2 or 3 feet below the surface, where, in moist condition, its under portions start to heat and are protected from cooling air currents.

As general conclusions, it may be said that some kinds of coal are more liable than others to spontaneous heating but that all bituminous coals will heat if the conditions of storing are of a favourable kind. Large deep piles, over 15 feet in depth, are always dangerous; a large percentage of dust is one of the biggest elements of danger; a mixture of fine coal with a small quantity of lump, which provides access to a limited supply of air, affords an ideal state of affairs for heating; freshly mined or freshly crushed coal heats more easily; by re-handling after 2 months' storage further risk can probably be avoided; moisture and sulphur are possibly dangerous factors in starting the initial heating, but the importance of their influence is hardly as yet established by experimental evidence.

A NOTABLE SKYSCRAPER

NEW YORK is the great home of the skyscraper. The reasons underlying this are probably only realized in part elsewhere. In the first place, consider the broad fact that, while fairly tall buildings are scattered over Manhattan Island—the chief district of the city—the significant fact still remains that nearly every exceedingly tall building is located in the extreme downtown section. A notable exception is the tower of the Metropolitan Building—one of the tallest buildings in the world. This structure is at the corner of Madison avenue and Twenty-fourth street, about two miles north of the southern extremity of the Island. Another exception—a mile further north—is the *Times* Building. Speaking generally, however, the very high buildings are situated far to the south—within a mile of the extreme southern end. Here is the financial district. Land is held at very high figures. In order to realize to advantage on the investment necessary for the site, a building must ordinarily be run up into the air. Further, the immense number of tenants that can be housed in a single tall building brings about a geographical concentration of various interests which, no doubt, greatly facilitates business. To these considerations may be added the fact that the skyscraper is a popular type of building with tenants. A location on the tenth, fifteenth, twentieth or twenty-fifth floor is not at all objectionable. The light is good, the air pure, the view fine. Access is rapid and certain, due to the usual generous equipment of elevators or lifts. For example, the Hudson Terminal Buildings are two structures of about twenty stories each. These buildings are filled with the offices of important concerns, many of which have home offices at various points throughout the country. One of these buildings is provided with eighteen lifts, the other with fifteen lifts. The general practice is to devote certain lifts to the purpose of express business—that is, the transport of passengers between the ground floor and floors higher than, say, the tenth. The first stop going up, for example, would then be the tenth floor. By such arrangements quick transportation is obtainable to all floors. The development of lift service has, in fact, made the tall building possible.

Of the skyscrapers in New York, the most notable are the Singer Tower, the Metropolitan Tower, the Woolworth Building (under construction), the Bankers' Trust Company Building, the City Investing Building and the Whitehall Building. All of these have more than thirty stories each. With the exception of the one in course of construction, the Bankers' Trust Company Building is the most recent. This is, in a number of ways, a very notable structure. It may, in fact, be regarded as embodying the highest achievements in skyscraper construction. It has been built by people to whom cost has probably been a minor consideration. It stands on the north side of Wall Street one block to the east of Broadway. It is thus in the very centre of the financial groups. As one approaches New York by steamship, this tall building, thirty-nine stories high, is a prominent mark on the

THE BANKERS' TRUST COMPANY BUILDING, NEW YORK, SHOWING THE STRUCTURAL SUPPORT OF THE STONE ROOF

skyline. It stands as a tower capped by a slender pyramid. Close attention reveals the pyramid as having the structural form of the famous Egyptian prototypes. That is to say, the faces are stepped or terraced. Below the tall pyramidal cap is a colonnade, consisting of heavy double columns. These occupy the levels of the twenty-seventh, twenty-eighth and twenty-ninth stories. Below, the building is severely plain for twenty-two stories, when a second colonnade begins. The columns here are single, and have about the same height as those on the upper level. The lower colonnade is quite close to the street. The entire building, from street to apex, is faced with stone. Even the pyramidal roof is of this material.

The main body of this rock tower is covered with window openings. There are five groups of two each, corresponding to each floor. Between the two colonnades there are thus 220 windows on one façade. The whole structure—pyramidal cap, heavy colonnade, regular body, with accurately placed and numerous openings and basal portion with its colonnade—presents a beautiful and impressive appearance, free from ornate decoration. The tower makes its appeal to our approbation for the simple and the substantial.

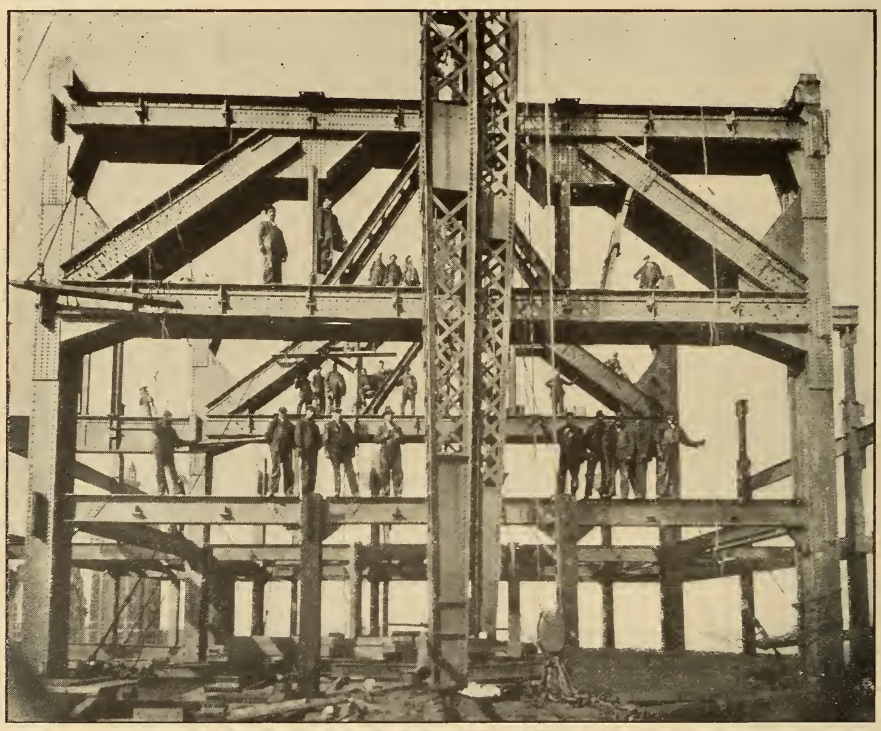
It will readily be granted that one of the great questions in connection with the modern skyscraper is that of the foundations. There are tall buildings whose masses are only indirectly supported by bed-rock. Some float, as it were, on masses of concrete; others rest their weight on masses of piles. The present tendency in New York may, however, be said to be distinctly in favour of considering nothing but the bed-rock itself. Because of subsurface conditions in lower Manhattan Island, the foundations of buildings directly on the rock often present a formidable problem. The rocky strata are frequently 75 or 100 or even more feet below the curb. The level of perpetual saturation is soon reached as one descends below the surface. In fact, between the street level and the bed-rock are, in many localities, great pockets or layers of quicksand. These are sometimes under pressure because of buildings in the neighbourhood carried on "floating" foundations. Often neither sand nor water could be pumped out of an excavation, unless in connection with extraordinary precautionary arrangements to prevent the withdrawal from the surrounding buildings. The method almost universally pursued at present is to sink concrete footings by means of the pneumatic caisson method. The procedure in a typical case is substantially as follows: A working chamber is constructed of wood or perhaps of reinforced concrete. This has no bottom; its roof is perforated by a central opening, above and around which a large steel tubular shell is arranged. At its upper end this tube is surmounted by a device known as an air-lock. All joints are made tight throughout the whole structure, so that when the open portion of the working chamber or caisson is below the water level and compressed air is introduced the working chamber can be kept clear of water. The workmen—"sand hogs," they are called—excavate at the bottom of the chamber. The "spoil" is conveyed upwards through the tube and air-lock, and is then disposed of at the surface. As excavation goes on and the caisson sinks to lower levels, the pressure of the air is increased, and the otherwise vacant space above the roof and around the tube is filled in with concrete. This procedure goes on until bed-rock is reached, when the caisson is filled with concrete and also the cylindrical space left in the strata of concrete already deposited. There is thus produced a heavy pillar of concrete resting on the rock. In the case of the Bankers' Trust Company Building a series of oblong caissons was sunk around the outer portions of the site. These were connected with each other, thus forming a cofferdam six or seven feet thick. A horizontal layer of concrete three feet thick was also put in, the result being a great cup of concrete separating the basement stories—four in number—from the surrounding hydraulic influences. In order to withstand the tremendous pressures tending to crush the cofferdam inwards, great steel girders have been used to brace the walls.

Counting basements, the building is forty-three stories high. In the lowermost basement are installed the heat and power generating apparatus. In the basement just above are located ventilating and other equipment, with the result that the building proper is cut off from the heated atmosphere of the lower basement. The two floors immediately below the sidewalk

are occupied by the great vaults with their walls of armour plate steel.

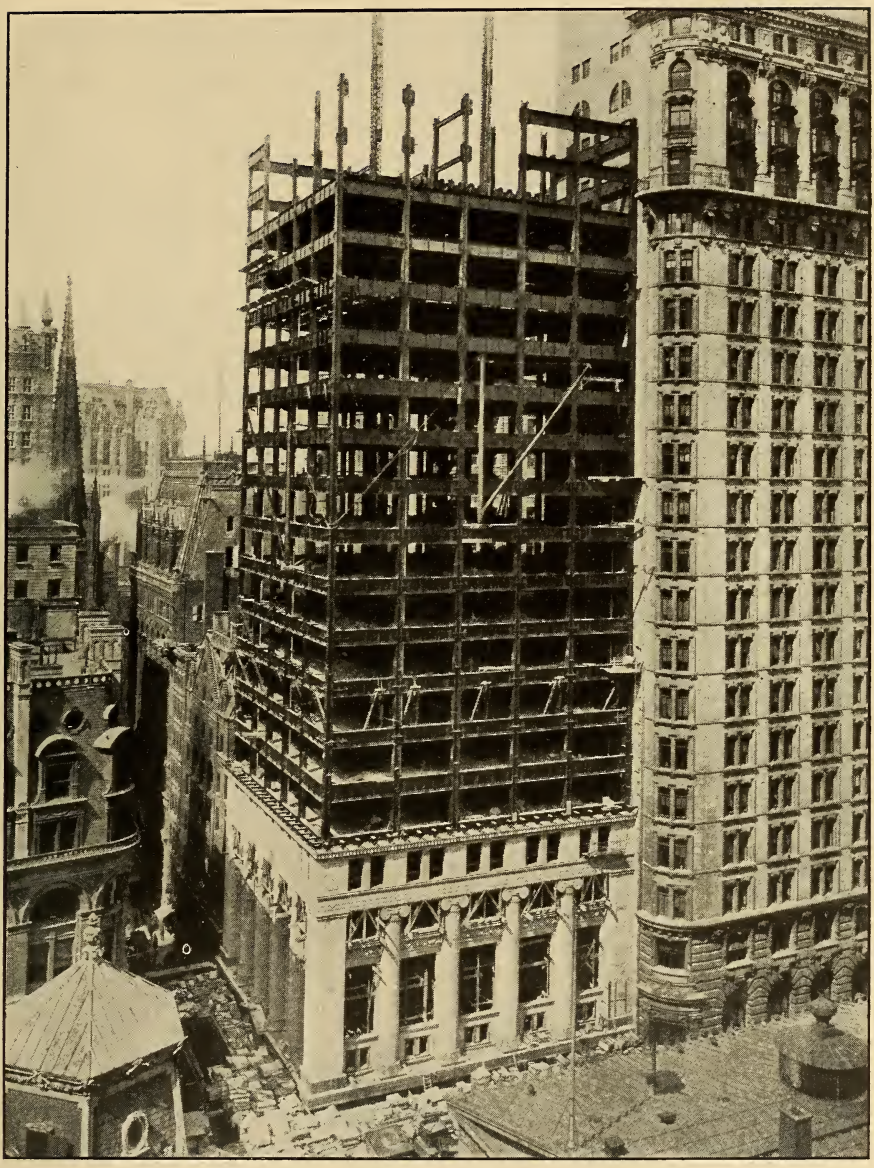
The framework of the building is of steel throughout. The exterior wall masonry of the floors is, in general, carried by the framework. The wall for each floor is carried on its own individual support.

It is the ordinary practice for the vertical steel supports to be run continuously from the footings upward. In the present case, however, it was desired to provide a great banking room on the second floor free from columns in the centre. To provide for this requirement, recourse was had to the supporting ability of the steel truss—familiar in bridge construction. However, in introducing this device into the tall building, the question of the prevention of appreciable vibration enters. The problem was solved in this Wall Street building by the use of four trusses, each about 12 feet deep. Two of these were situated at the level of the twenty-ninth floor and two at the level of the fifth floor. The upper trusses support the central columns reaching from their level to the top of the building. The lower trusses perform a double duty. In the first place, they similarly carry the interior columns above them; in the second, they support the central portions of the two floors below. The second floor is thus provided with a clear space in the middle of the great banking room. This room has a height of about 30 feet and is about 90 feet square in floor area. Intermediate between the centre and the walls are placed great fluted columns pleasingly intermingled with others square in horizontal section. The result is a noble room—one of the greatest banking rooms in the world.



STEEL TRUSSES FOR SUPPORTING INTERMEDIATE FLOORS, BANKERS' TRUST BUILDING

The usual floors above the Trust Company's section are being taken up largely by brokers, and the like. The



BANKERS' TRUST BUILDING UNDER CONSTRUCTION

suites of offices are among the finest in the city—light, easily accessible, having a splendid view. That such offices are highly desirable may be judged from the yearly renting rates—$21,500 for an entire floor; $3.50 per square foot of floor area for offices not on a corner; $4 per square foot for corner space. These prices include heat, ventilation, etc. These figures probably represent the very highest rates charged by any considerable building in New York.

The interior space of the pyramid is devoted, in part, to a large number of storage rooms, where account books, and the like, may be kept. These rooms are provided with automatic sprinkler devices. In case a fire begins in one of the storage

rooms, the apparatus is automatically started and water is thrown on the contents. The tank supplying the water is housed in the pyramid. Mechanical accessories of the lift system are also accommodated in the pyramidal interior. In fact, the pyramid serves not merely as an architectural feature, but also as an envelope to screen unsightly but necessary adjuncts of lofty buildings.

There are a number of minor features about the building of interest to those concerned with office building construction and equipment. The building is highly fireproof. For example, the framework of interior openings and the numerous doors are of all-steel construction. The art of manufacturing steelwork of this description has been carried in the United States to a very high degree of perfection. Thus, a steel door may be made to present precisely the appearance of polished mahogany. The imitation is no clumsy one, but such as to leave the expert satisfied. The exterior openings are provided with window frames, and the like, made of wood, over which a sheathing of metal has been drawn. Cork flooring has also been used at different points, providing a silencer of the footsteps. The doors through the greater part of the building are provided with the Yale system of master-keyed locks. These are so fashioned that all the locks on a single floor can be opened by means of a master key in the hands of the superintendent of the building. Further, a grand master key serves to open all the locks commanded by the various master keys. In the department occupied by the Bankers' Trust Company a distinct master key is capable of unlocking the locks of the various desks, filing cases, etc. This key is to be kept by an official of the company. There are about 1,500 of these Yale locks in the building, made by the Yale & Towne Mfg. Co., of New York. The architects of the Bankers' Trust Building were Messrs. Trowbridge & Livingston; the structural steel work was erected by Messrs. Post & McCord; and the granite work was furnished by the New England Granite Works. The building is equipped with Otis elevators.

LOOKING FORWARD

EDITORIAL NOTES ON IMPENDING DEVELOPMENTS

ABOUT twenty-five years ago there was published a book which attracted much attention, and which bore the suggestive title "Looking Backward." This story, purporting to give a view of social conditions at a distant future period, "looked backward" at the state of affairs in the latter part of the last century, and thus enabled, to a certain extent, the author's views of social development to be incorporated in the story.

It is not necessary to produce a work of fiction to emphasize the changes which are continually going on about us, and it requires no very strong effort of the scientific use of the imagination to indicate the manner and extent of the influences which the rapid development of applied science is certain to exert upon the affairs which are directly ahead. It is proposed to discuss, in the following pages, both in this issue and in succeeding numbers of this magazine, some of the indications of coming changes, and without essaying the part of prophecy, to look just a little ahead at the problems which appear to be in almost immediate process of solution. These will cover many fields of activity, and may offer both probability and suggestion, furnishing material either for speculation, opportunity or discussion.—THE EDITOR.

Past and Present.

Nearly every important thing which affects the conduct of life to-day we owe to some one who is no longer living. Few men live long enough to see the fruition of their work, and that man is fortunate who can see his efforts begin to influence the community.

The navigation of the air, barely started, is yet guided by Lilienthal, Langley and Wilbur Wright. The rush of the automobile received its impetus from Daimler, Lenoir, Hancock, and Goldsworthy Gurney. The whole immense development of applied electricity is bound up in the fundamental work of Faraday, Gramme, Ruhmkorff, and Joseph Henry.

In nearly every instance the man's life is done just about the time that his work begins to live. There are exceptions, and we still have with us Bell, Edison, Thomson, and Diesel, but in industry, literature, government, art, education, by far the most powerful influences are those exerted by men who are gone, but whose works still hold us firmly in their grasp.

Science is always ahead, and it is the rest of the world which is tardy. The need of the time is a swifter grasp of the possibilities of applied science; the good things are many and just ahead, and it is not impossible to reach out and meet them as they approach.

Mechanical Warfare

The importance of manufactured power is now so generally conceded in all industrial operations, and the inefficiency of human muscle, considered as a means of performing work, is so fully recognized, that it seems strange that in the oldest department of effort, that of warfare, so much dependence should still be placed upon men. The value of armies is still estimated according to the number of human beings contained in them, while in the steel-mill and factory the efficiency of

the plant is indicated by the reduction in the number of operatives; the best managed establishment is that which counts the largest output for the fewest hands. When it is considered that armies are to-day regarded by the ablest statesmen as means of maintaining peace rather than of conducting warfare, it seems curious that methods which are known to conduce to maximum efficiency in civil engineering should not be given a little more consideration in the military department of government. Probably this is due to the extent to which military conservatism holds aloof from general progress in other departments of life and work, but there is little doubt that hereafter we shall have national police work done more and more by machinery and less by the older inefficient methods.

Foot and Vehicular Traffic

It is common for pedestrians to denounce the manner in which motor vehicles of all sorts dominate the highways, and make life upon the streets a continual nightmare to all who are obliged to go about. At the same time the owners and operators of vehicles object to the way in which foot passengers get in the road, and risk their lives before the speeding automobiles and omnibuses. Each desires some kind of legislation to control the other, and each is convinced that something must be done to remedy the trouble. There is a remedy, and one which, while proposed long ago, and repeated many times, has as yet not been brought into practical effect; namely, the segregation of the two kinds of traffic upon different levels.

Any attempt to limit the speed and freedom of the motor vehicle means the retardation of progress and the perpetuation of inconvenience. At the same time anything which debars the foot passenger from the entire freedom to traverse the highway in comfort and safety cannot be considered. The true solution appears in the segregation of the two kinds of traffic in two different levels, reserving for vehicles the surface of the ground, and providing for the pedestrian a continuous level above, upon which he can pass freely and safely, and enter and leave buildings regardless of the speed or direction of anything upon a lower level. Such a solution is certain to come before long in the more congested portions of great cities, and it will ultimately be found desirable in all parts of countries in which power-propelled vehicles are used.

The Passing of the Railway Terminal

It has been predicted that the two great railway passenger terminals in New York City will be the last of their kind to be built in the United States, and it is entirely possible that this is true. The plan of gathering large numbers of people from many points and delivering them in a confused mass all together at a point varying from a quarter of a mile to five miles from places where they desire to be, is a crude survival from the time when cities were smaller and travelers much fewer in number. In the modern city the railways bringing passengers from all parts of the country will necessarily be operated as portions of the local transport systems, so that the entire city will form the terminal, and the train, passing the round of the underground railway, will permit individuals to descend at stations reasonably near to their personal destinations. Such a service will so far outweigh any idea of the desire for imposing architectural terminal structures that it is already evident that the railway first providing such distribution of its passengers will materially outdistance its rivals. Already, in New York, the co-operation of the Hudson Tunnel system with the Pennsylvania Railroad is making the new terminal station of the latter railway obsolete, and is showing the way to provide for the real convenience of the traveling public. What the result would be if the entire subway system of the city formed the true terminal of all rail-

ways permitted to enter, may well be considered before any more great stations are built.

Kinetoscope Possibilities

The extension of the art of moving pictures from the field of amusement to that of scientific observation is becoming a reality. Several years ago it was noted that the possibilities of continuous film photography indicated a method of investigating movements and operations which occurred too rapidly to be properly studied by the unaided eye. The microscope permits the examination of things far too minute for study by ordinary vision; the telescope brings distant objects near; the microphone magnifies feeble sounds; the stroboscope permits the study of rapidly revolving bodies, and gives instantaneous glimpses of swiftly moving objects. To these must now be added the practicability of using the moving film for recording the sequence of rapidly moving parts in such a manner as to allow them to be studied subsequently at much slower speeds.

By running a film, for example, at an extremely high speed, before a piece of material under test at the moment of yield, and then passing the same film much more slowly through the projecting lantern, the successive phenomena of rupture may be seen and studied at leisure, all details appearing in correct sequence at a rate slow enough to allow the eye to perceive them. Recently this method has been used, in connection with a glass cylinder, to study the scavenging action in combustion engines; and as the apparatus is perfected, it is evident that there is here a most valuable instrument and method of scientific research.

The Burden of Precedent

Precedents are always useful if wisely used, but it is well known that those departments of work which depend largely upon the influence of precedent are handicapped with a heavy burden, and often lag far behind the rest of the procession.

The walking beam which was found so necessary to enable the original Cornish engine to reach out over the edge of the pit and be connected to the pump rod, was servilely copied for many years when the pump was replaced by the crank and the engine required to drive rotating machinery. It took several generations for the precedent of the reciprocating piston in a cylinder to make way for the rotor of the steam turbine; and a similar process of evolution is still under way with the combustion engine.

Designers of combustion engines for the production of air blast are yet working under the influence of the great reciprocating blowing engines whose "tubs" themselves are a survival of the time when they were connected to a slowly moving waterwheel. This in the face of the fact that lightness of weight and high rotative speeds are special possibilities with the combustion engine, and that multiple rotary blowing machinery has been highly perfected and is waiting to be employed.

It is well known that many great improvements in various departments of applied science have been made by "rank outsiders," largely because these men have been free from the heavy burden of precedent, and thus capable of considering their subjects upon their merits, regardless of past methods.

Harbour Limitations to Shipbuilding

Several years ago an attempt was made to study the conditions governing the increase in the dimensions of seagoing steamships, and by laying out a diagram, with the periods of time as abscissas and the lengths of vessels as ordinates, it was possible to plot a curve which, in a general way, indicated the rate of growth. Leaving out of consideration the *Great Eastern,* which was well understood to be an exception, it was seen that the development followed a fairly

smooth curve, and it was thought permissible to prolong the curve for a short distance and draw some conclusions as to dimensions to be expected in the immediate future. It thus appeared that if no disturbing elements entered into the matter to alter the recent rate of growth the 1,000-foot vessel might be expected by about 1920.

It is altogether possible, however, that certain modifying elements will enter, and that the rate of increase will be less rapid than former developments indicated. This may be partly due to the influence of the disaster to the *Titanic,* which, whether justified or not, may have created a prejudice against very large ships, at least to a sufficient degree to lessen their value in attracting travel. It is almost certain to be caused, however, by the fact that the limitations of harbour capacity are being rapidly approached. These limitations include both length and depth, although the latter is the one most necessary to be considered. In New York there has already been difficulty in providing for the latest and largest vessels, and similar obstacles have also been encountered in other ports. The matter of depth of channel, however, is more important, since greater depth is essential for the stiffness proportional to increased length, and the deepening of existing channels and harbours is a serious and extremely expensive undertaking.

The two great gauges, so to speak, of the draught of vessels, are the Suez Canal and the Panama Canal. At Suez, the increasing demands of traffic have caused the waterway to be repeatedly enlarged, and the works now under way will provide a depth of 36 feet of water, permitting steamships with a draught of 31½ feet to pass. This work, however, will not be completed until the close of 1913. The Panama Canal, which will doubtless be able to pass vessels about the same time, although it is not to be opened officially until 1915, will have a minimum depth of 45 feet and be able to receive vessels drawing 40 feet of water. Notwithstanding the fact that these great waterways have not as yet been called upon to receive the greatest of modern vessels, it is entirely possible that such demands may be brought upon them, and with such developments in sight the shipbuilder will have to keep these limitations of draught, with their influences upon other dimensions, continually before him.

Leaving, for the moment, the fact that the commerce of the world must in future be carried in vessels which can pass through either or both of the great canals, we may consider the limitations of the principal terminal harbours. At the present time the greatest trans-Atlantic liners are in the service between Liverpool or Southampton and New York and between Bremen or Hamburg (or rather Bremerhaven and Cuxhaven) and New York. At the New York end, the Ambrose channel is supposed to provide a depth of 40 feet, but this is within comparatively narrow limitations; but we may assume a maximum depth for New York of 40 feet at low water and 46 feet at high water. The British ports, owing to the greater range of the tides, offer more marked differences than New York, the depths at Liverpool, for example, being 54 feet at high tide and 37 feet at low tide, while at Southampton the depth, until recently, was only 32 feet at low tide and 45 feet at high water. The new deep-water dock, however, constructed for the *Olympic* and vessels of the same class, provides a depth of 40 feet at low water, with an additional 13 feet at high tide. The maximum low-water depth at the London docks is 30 feet, but the importance of providing better accommodations is indicated by the fact that the proposed newer docks are to have a low-water depth of 38 to 44 feet.

The new harbours at Rotterdam are to have a minimum depth of 33 feet, corresponding to 38 feet at high water, while at Antwerp the present harbour offers a depth of 30

feet, with a proposed increase to 37 feet.

These facts all indicate that the next great public work to be undertaken by the principal maritime nations will be the improvement of harbours, and especially the deepening of channels and improvement of entrances. The Panama Canal construction works have been only the beginning, and, unless the principal harbour entrances are improved to correspond, the limitations of commerce will appear everywhere else. The engineer will have to provide methods to open channels, and, what is more, to keep them open. Dredging will do part of the work, but the conditions which have led to the formation of bars and the shoaling of harbour entrances should be studied, and the forces which have acted to move the mud and sand in undesired directions may be enlisted to scour out and maintain passages which will keep the channels open.

Probably the best results will be attained by a combination of both methods, using modern powerful dredges to cut deeper channels, and also by constructing properly designed reaction breakwaters to direct the ebb and flow of the tides to deepen still further the waterways and prevent shoaling of the work already done. Until the harbour engineers upon both sides of the ocean act in concert with the builders of vessels to provide channels commensurate with their work, it will be useless to attempt to predict the developments in shipbuilding for coming years.

The Mechanical Propulsion of Sewage

In the design of a sewerage system one of the important things heretofore considered has always been the proper slope of the various conduits, in order that the velocity of flow may correspond to the delivery or movement of the contents. The slope, cross-section and character of surface, in fact, form the three elements which enter into nearly all computations for the amount of liquid which a conduit will carry, and much study and elaborate calculations may be found devoted to this portion of the subject. In localities in which the character of the ground provides ample opportunity for selection of satisfactory grades for sewers the methods developed along such lines have given good results, but there are many cities situated in such level plains that the grades have to be made less than is really considered desirable, and in such cases it has sometimes been found necessary to resort to pumping. This method is by no means new, and indeed it has a prototype in the well-known arrangement of the drainage canals of Holland, in which the numerous small ditches flow into larger collecting canals, the contents of which are cleared over the dikes into the sea by paddle-wheels or Archimedean screws driven by wind-power. A recent example of mechanically propelled sewage on a large scale is seen in the new drainage plant for the city of New Orleans, in which a system of collectors and pumping machinery is operated to direct the flow into Lake Pontchartrain.

An interesting application of the propulsion of sewage by mechanical means appears in the installation recently made in Brooklyn, New York, in connection with the old Gowanus canal. This canal, constructed many years ago to provide a navigation entrance from the East river to a manufacturing district, was a so-called "dead end" canal, so that no continuous flow through it was possible; and the ebb and flow of the tide was assumed to be sufficient to renew the water and to prevent any accumulation of impurities. For a time this action, together with the volume of storm-water which drained into the channel, answered the purpose. With the increase of population and manufacturing much household sewage and factory waste entered the canal, and the water became foul and offensive, the accumulation being greater than the feeble action

of the tides could remove. There has now been installed a system of mechanical propulsion, consisting of a propeller pump, 9 feet in diameter, placed in a tunnel communicating with a sewer discharging into the Buttermilk channel. This propeller is driven at a speed of 120 revolutions per minute by a Westinghouse electric motor of 400 horse-power, controlled by suitable switchboard and transformer equipment, a flow of 30,000 cubic feet of water per minute being maintained and the canal being kept entirely cleared of all accumulation of stagnant matter.

This simple solution of a problem which had long been an objectionable feature of an important locality suggests the possibilities of certain modifications of the method to many other places. When a fairly high velocity is maintained in a pipe, sewer or other conduit, its capacity is increased in proportion to the increased speed of flow through it. Its transporting power, however—that is, its capacity for carrying solid matter along with it—increases as the sixth power of the velocity, so that if the velocity in a channel is doubled it will carry twice as much water, but its transporting power will be increased by an amount expressed by two raised to the sixth power, or *sixty-four* times. It is evident, therefore, that a very moderate increase in the velocity of the flow of water through sewers would enable much smaller conduits to be used than in the case of the slower velocities, due to gravity and moderate slopes, while there would also be a continual *flushing action,* which would entirely prevent the accumulation of any sediment and would permit the use of such sewers for the removal of almost any solid material dumped into them.

It is possible that there is here the germ of an entirely new system of street cleaning operated in connection with a mechanically-propelled sewerage plant. In Paris, as is well known, it is the custom to keep the surface of the streets clean by washing them with water supplied through hose, all the surface dirt being flushed into the sewers; and the expression *tout a l'egout,* or "everything into the sewer," is well known in that connection. If, however, the sewer, to fulfill this double service of carrying both liquid and solid refuse, is provided with a mechanical system of propulsion and its contents maintained at a high velocity, such a system is given an enormously increased importance and availability. In cities such as New York, Philadelphia or Pittsburg, for example, lying between two rivers, there might be placed beneath the cross streets sewers of moderate diameter, taking in water from one river and delivering it to the other, a continuous flow at high velocity being maintained by means of a propeller pump electrically driven, the intake and discharge being below the surface of the river and a rapid rush of water being maintained at all times. Numerous openings from the surface of the street to this torrent would permit all street cleanings, snow, garbage and refuse of every kind to be dumped into this conveying system without fear of obstruction and with the least possible interference with surface traffic. The sewer in such a system would replace almost entirely the use of carts for hauling refuse and reduce the work of street cleaning to the operations of sweeping and washing the dust, dirt and other material into the dump holes communicating at frequent intervals with this underground hydraulic conveyor. In cities in which only a single river is available, the intake would necessarily be upstream, the sewers passing through the city in curved paths and delivering into the same stream below the built-up portion.

The amount of power required to maintain a fairly high velocity in such a conduit need not be great, since the water is not elevated materially in height, and the principal resistance to be overcome would be that due to the friction of the flow against the walls of the sewer. Such a sewer might well be built of rein-

forced concrete, the hooping providing ample resistance to bursting stresses, and all connections moulded in place. In considering the cost of construction and operation of such a system it should be remembered that it might properly be compared, not only with the cost of ordinary sewers of large size, but also with the operative cost of collection and haulage necessary with the old method of street cleaning but superseded by this operation of hydraulic conveying.

So far as household wastes are concerned, such a system would provide a convenient and ever-ready dump for all waste material, removing entirely all necessity for retaining it until the arrival of a collecting wagon and permitting a continuous clearing operation. Incidentally, there would be no opportunity for the accumulation of sewer air or decomposing material, and thus the wastes delivered into the river would be far less offensive and much more readily disposed of than material which had been permitted to remain for a longer period of time. The velocity with which the discharge from such a system would be delivered into the river could be so controlled as to cause it to be carried well out into the channel, where the velocity of the current would insure its transport out to sea, and avoid the accumulation of solid material about the outlet. The high degree of dilution provided by the excess of water would entirely prevent any highly concentrated and offensive sewage from being formed. The discharge being made below the surface and at high velocity would effectually prevent access to the material by disease-carrying insects, and thus remove any menace of infection at all times.

One of the important causes of congestion in city streets is found in the obstruction due to slow-moving vehicles, such as street cleaning carts, as well as to snow piles, heaps of rubbish, etc., and the elimination of this element would be found of material aid in maintaining unobstructed traffic. In this respect the plan suggested is but one of many which demand consideration at the present time. The possibilities of performing the greater portion of our activities by means of properly directed power are only beginning to be realized. It would be almost impossible to conduct business in a modern crowded city if people were obliged to move about by their own efforts, and it is only by the introduction of electric transport and mechanical lifts that extreme congestion is avoided; and if it were not for the telephone, enabling a vast amount of business to be transacted without entering into actual contact with others, we should already be checked by the mere physical limitations of ourselves. It is altogether possible that the crowding of people in great cities may be vastly diminished, not by providing better transport facilities for people, but by the development of methods for reducing the amount of personal and vehicular movement necessary, and the mechanical transport of refuse by hydraulic conveyors may become an important element in this method of relief.

Concerning Noise

There have been many attempts to define just what is meant by the term "efficiency," which is so much under discussion at the present time. It is agreed that the ratio of effect to effort expended is a fair definition; but this, like many other definitions, comes after the event, and only tells us how much we have lost and not where the loss has been incurred. The practicing engineer knows that the true method of increasing efficiency lies in the reduction of wastes, and that the important matter is the detection of wasted effort and the curtailment of the non-productive expenditure of energy, since we may, in nearly all cases, cut out a large proportion of the losses as soon as we are directed toward their whereabouts.

In determining the efficiency of a prime mover, such as a steam engine,

an internal-combustion motor or a water-wheel, the engineer endeavours to measure the energy delivered into the machine, either in the form of a certain number of pounds weight of steam of a stated temperature and pressure, or in the form of a definite quantity of fuel of a tested calorific value, or of a positive weight of water falling through a measured head, and then to compare this with the measured amount of energy produced by the machine. This latter value is determined, either by a power-absorbing brake, or by the conversion of the energy into electricity, making it capable of measurement by a watt-meter, and thus we obtain the two values whose ratio expresses the efficiency of the operation.

It does not always help, however, to know how inefficient our power conversions are, since we are no better off than before if we do not know how to reduce the losses. The physician exercises much care in making his diagnosis, in order to discover just what ails the patient; but he does this in order to decide what remedy to apply. The engineer, like the physician, applies his instruments and his observations to discover the nature and cause of the ailment, and if he is wise he uses the results of his investigations to direct the energy at his disposal toward the increase of useful effects and the reduction of those absorptions of power which cannot be utilized.

We generally know what we desire to accomplish—either to cut metal, as in machining operations; to move material, as in excavating, pumping or transport, or to produce light or heat. We also know what we do *not* desire to produce, and among the undesirable products are generally included noise, dirt and obstructions to progress. The maximum degree of efficiency will undoubtedly be attained when the desirable products are a maximum and the undesirable ones a minimum.

Confining ourselves for the present to one of the undesirable and wasteful products often accompanying the application of power, we may consider the element of noise. In a few instances noise is desired and useful, as in the case of the foghorn, the siren, or other instrument of warning; and it is a matter of passing interest to note that when noise is really desired for such purposes we find that it consumes far more power for its effective production than we had ordinarily imagined. In most cases, however, the production of noise is wholly undesirable, and the power which is expended in its making is worse than wasted, since it is not only not useful, but produces distractions which either directly or indirectly detract from the comfort and efficiency of all within its range.

There is one thing about noise, however, which is to its credit: it is an unfailing indication of its own whereabouts. Some avenues for the escape of power are difficult of detection. Friction is often silent, and only reveals its location and extent when the heating effects become apparent. In the production of light we know that much unused heat must be generated before the high-speed vibrations of light are attained, and not until the production of cold light is achieved will this silent source of loss be cut out. The power wasted in the production of noise, however, is always evident and never concealed; it thrusts itself upon us, clamoring vigorously for notice, and telling us in unmistakable language where the power is being consumed, and how worse than uselessly it is being wasted.

One of the surest indications of perfection of action in any piece of machinery appears in noiselessness of operation. We know that the thumping and pounding steam engine is less efficient than one which is running smoothly and silently, and it is apparent to the casual observer that the noisy machine is wasting all the

power required to create the disturbing sound waves. In the great hydraulic power plant the real efficient work is not performed by the noisy torrent which is splashing over the spillway; it is stored in the great silent mass held back behind the dam, while the useful power is effectively generated by the quiet column of water descending through the penstock and imparting its energy to the turbine with the least practical waste in noise-making.

The same considerations obtain in other departments of work, and the experienced engineer knows very well that any installment of machinery which is creating a great hubbub and making more noise than the results warrant is operating at a lower efficiency than would be the case if less noise were produced and more of the energy were devoted to useful effect.

An excellent example appears in the case of a locomotive starting a heavy train upon slippery rails. When the engine is first started there is a great noise of puffing exhaust steam, the driving wheels slipping upon the frosty tracks, and little or no effort being expended in moving the train. As soon as the wheels begin to bite upon the sanded track and the train begins to move the barking noise subsides, and the effort of the steam in the cylinders, being expended upon useful work, ceases to be wasted in producing useless noise, and acts quietly to develop efficient transport, the noise disappearing as soon as the useful work begins. A similar instance appears in the starting of an automobile, which ceases making a noise as soon as it begins to perform its forward movement, and numerous other examples might be mentioned.

Notwithstanding these obvious illustrations of the manner in which noise indicates wasted energy, we find ourselves surrounded by violent and distracting noises in nearly all the activities of daily life.

If we stop to think for a moment, we know that the disturbances which are so evident in the atmosphere represent, not only excessive annoyance, but also avoidable waste. In spite of this continual demonstration of inefficiency, there appears to be little or no effort to reduce the loss which is so apparent and so destructive. The operations of transport, of manufacture, of communication, and even of relaxation, are so immersed in meaningless and wasteful noises that it might almost seem that we had been deprived of the organs of hearing and were unaware of the continual protest with which our ears are being assailed.

In some departments of work, however, attempts have been made, with more or less success, to reduce the amount of noise involved in the operations of business. The earlier telephone apparatus, involving the grinding of a crank and the ringing of a bell to call up the central station, has been replaced by the silent flash of light which takes place immediately when the receiver is lifted from the hook.

Again, efforts are being made, and with success, to do away with the continual "tap tap" of the typewriter by the introduction of machines in which the printing is effected by pressure instead of by blows, thus removing entirely the distracting noise so general in any office in which correspondence is being conducted. Probably the reduction in efficiency due to this particular form of noise has never been estimated in its full magnitude; but investigation would doubtless show that much fatigue and many mistakes have originated in the unconscious influence of such noisy surroundings.

The principal opportunity for the reduction in noise and the removal of the accompanying losses appears in the streets of our great cities. It has already been pointed out that one of the great sources of loss in the handling of merchandise lies in the defective connections between the long-distance transport systems, the railways and steamship lines, and the manufacturing establishments and

warehouses which they serve. The use of animal traction, involving expensive handling in loading and unloading, also includes the noisy rumbling of teams over imperfectly paved streets, and the "roar" of a great city is largely due to this preventable and objectionable relic of mediævalism.

Here, as elsewhere, the production of noise is an indication of general inefficiency, and methods which would relieve one would necessarily improve other portions of the operation. Instead of rehandling material, a proper arrangement and location of terminals in connection with manufacturing establishments would enable nearly all the noisy hauling to be avoided, and with the noise much of the unnecessary cost would disappear. This plan has been already adopted to some extent and its practicability fully demonstrated.

Another kind of noise in city streets is that due to the use of various kinds of gongs, whistles and other instruments of warning in connection with the operation of electric street cars, automobiles, etc. It seems to be the common belief in this respect that the louder and more offensive the noise, the more effective the warning, although experience has long since shown that it is not the loud noise, but the one which is different from others, which is most readily perceived and heeded.

There should, however, be no reason for any warning noises at all in connection with the use of power vehicles in cities, since such machines can only be operated at their best efficiency when given a clear right of way and relieved from the requirement of warning passengers. The entire segregation of vehicular and foot traffic, already often considered, and readily provided by the use of elevated footways, would solve entirely, not only the necessity for the use of any warning noises, but—as in most other cases—would bring with it a general increase in efficiency in the entire operation of moving about.

Another source of noise, and one which demands especial attention, is that involved in the removal of débris and rejected material, including the handling of garbage and ashes and the cleaning of streets.

Attempts to perform this undesirable work at night has been found difficult, and, in some cases, impracticable; and often the disturbance of the noise by night has been considered more objectionable than by day. The noisy portion of the operation consists mainly in the dumping of cans, barrels and other receptacles into the wagons, with the inevitable accompanying disturbances.

It will be seen that, with the elimination of the noises due to warning gongs, to street cleaning operations and the operations of heavy hauling, much of the distraction now existing in large cities would disappear. Elevated railways would probably continue to make their usual amount of noise, but it is probable that no more such structures of this kind will be built, or, if their construction is found necessary in special locations, a more massive and less resonant design may be adopted. These are but a few of the instances in which immediate opportunity for the elimination of noise may be found, but it will require no very great effort to discover many others. The extent to which noise aids in determining its own location and the means for its removal will greatly aid in this respect.

The great thing to be done is to bring about a realization of the fact that noise means inefficiency, and that anything which aids in reducing noise means an increase in efficiency, not only in the operation immediately concerned, but also in the affairs of all within its range. Possibly the secondary effects of the removal of noise may be greater than those which are more immediately apparent, and that the improved health, activity and comfort of the whole community should be the prime considerations in bringing about the elimination of this senseless source of waste.

Technical Education

The training of a boy, so far as his regular education is concerned, may be considered as commencing at about his tenth year, the period before that age being so elementary in character as to be assumed as standard. From the tenth year, however, the foundations of his education must be laid, the superstructure erected, and the work carried on to a point where it is followed by the period in which the knowledge acquired begins to be used, and also to be supplemented by that practical training of experience which is to continue throughout his life. If the youth, after a full school education, is sent to the university, it follows that the education, strictly so called, the period of study preceding entrance into active life, will last until about the twenty-first year of his age, or, in other words, the formal education of a young man will extend over a period of more than ten years.

Any critical examination of the development of any kind of public affairs, technical work, commercial methods, politics, industrial progress, or useful activity of any kind, will demonstrate that under modern conditions the changes certain to occur in a decade are very great. They cover not only apparatus, devices of manufacture, methods of work, and conduct of affairs, but include modifications in the fundamental ideas governing all the activities of life. Trade centers shift, political doctrines governing the life of nations become out of date, entire manufacturing equipments become obsolete; personal, business and social relations are transformed. These obvious facts mean that during the actual time in which a young man is receiving his education the entire conditions under which he is going to use that education are changing, and that unless these changes are kept in view, and, so far as possible, foreseen, he will enter active life with a training almost as obsolete as the discarded methods of his boyhood.

It is interesting to note that these facts have long been perceived by engineers, and the attention of technical educators specifically directed to them, but as yet little or no modifications in methods of instruction have been made along these lines.

As long ago as 1895, the eminent engineer Mr. John Richards, addressing the students of Leland Stanford University, called attention to the slowness with which social changes take place, and said:

"A period of fifty years has been enough to change nearly all the processes and methods of manufactures, calling for an entirely new relation of workmen and their employers to the community; but fifty years can work but little change in social relations. It is not two generations, and there are men living now and working who were reared and learned their art under circumstances that have passed away. The progress made by science and the mechanic arts has no such limit of time. In ten years the change is more than a century can produce in the social relations of men. Science and discovery outrun social changes in such degree as to prevent comparison, hence the unrest and disturbance abroad in the land."

While it is not possible to compel social relations to keep pace with technical progress, there is room for a vast improvement in technical education, enabling it to keep very much closer behind actual progress than is now the case, and if this feature in educational matters was given intense attention, an immense improvement would be effected. It would call for a different class of teachers, text-books and methods, and the professor, instead of being the most conservative of individuals, would have to be the most progressive and advanced man in the entire community, and his text books the projected enterprises of the most active communities in the world.

It may be said that it is impracticable to foresee the manner and direction of coming changes, and this is, to a great extent, correct. It is possible, however, to avoid the expenditure of

much effort upon transient details, and to concentrate attention upon those fundamental elements which have thus far withstood in great measure the changes of scientific development.

There are, undoubtedly, some features in technical training which are of such a fundamental character that they naturally enter into all courses of instruction, these including the principles of the action of forces, the nature and behaviour of materials of construction, and the right use of mathematics. It follows that the grounding in these elements cannot be too thorough, the precaution always being taken to use methods which shall impress upon the student that these things are not ends in themselves but means to be used as tools in the attack upon the new problems which he is certain to be called upon to solve. Instead of working upon set questions, the solution of which requires only a certain facility in the application of text-book methods, the whole operation of examining a subject, stating the question, and selecting the method to be employed for the solution, should form a part of the work of the student. Self-reliance, the choice of methods, and the exercise of judgment are of far more importance in the development of the student than a parrot-like facility in handing back to the professor the information which he has previously handed out to the student.

While it is impracticable to indicate, in any course of instruction, any detailed lines along which current developments may be expected, it is evident that much greater foresight might be used than is general in ordinary modern methods of instruction. The development of the combustion engine as a source of motive power, carrying with it all the progress which has made the automobile, the aeroplane, and the utilization of furnace gases, preceded, in a most obvious fashion, the introduction of such subjects into courses of instruction. In like manner, the study of such machines as the steam turbine, the electric locomotive, the electric crane in all its applications, as well as the immense variety of handling and conveying machinery, has been deferred until such apparatus has been in common use, although the advent of such things could have been fairly well foreseen. The entire line of automatic and semi-automatic machine tools, both as to construction and application, has been a growth entirely apparent to the practicing engineer, although to the student it is by no means yet familiar.

The methods of the modern efficiency engineer are being inculcated in the minds of students largely by lectures and addresses by practicing engineers, and this method of bringing current problems into contact with the student shows how many other things might well be taught by others than the regular professors. The plan of using lecturers from various departments of actual practice is by no means new, but the very fact that such methods are found desirable emphasizes the lack of such practical and current experience in the regular courses of instruction.

It is not intended to deprecate the thorough teaching of the fundamental principles of the sources of power in Nature which are to be directed to the use and convenience of man, but these first principles may be reduced to few in number and made wholly clear in plain and simple language. If then the debris of past and obsolete methods are passed on to the scrap heap, there will be ample room for the extension of vision over the forward horizon, for the professor as well as for the student.

What is Good Fuel?

It is customary among engineers in discussing different kinds of fuel, especially in connection with the generation of motive power, to classify coals, for example, according to their availability in older methods of combustion. The high rating of Welsh and West Virginia coals, for example,

arises largely because they have been found so well adapted for use in the internal furnaces of marine boilers. Other coals are classified according to their heating value, the number of thermal units per pound, a plan which, from the viewpoint of the chemist and physicist, has much to recommend it, and which, all other conditions being equal, should properly appeal to the purchaser as well. The difficulty is that all other conditions are not usually equal, and that the real value of a fuel depends, not only upon the possible number of heat units in it, but also upon the method by which it is to be burned.

The valuable tests made at the St. Louis exposition, under direction of the United States Geological Survey, included the generation of steam by the combustion of coal under boilers, and also the production of gaseous fuel in producers, thus recognizing officially, so to speak, that there were other methods of getting power out of coal than had hitherto been considered in classifying fuels for power production.

Following upon this illuminating departure, it is now being recognized that some coals formerly regarded as of little value, were so considered merely because they were not adapted to the customary method of utilization. This brings out the point that there exists an immense number of fuels which, properly used, should be classified as good fuels, although formerly they were held to be little more than worthless.

In general, the development of the gas producer, and the use of gaseous fuels in the internal-combustion engine for the generation of power, have shown the way toward the production of greater efficiency in all kinds of fuels, but it has done even more than this in the extent to which it has leveled up, so to speak, the values of the different coals, because it has shown the way to use lean fuels in a rich manner. Lignites, formerly hardly considered worth mining, have been shown to possess a commercial value greater than coals of far higher calorific power, when the lignite is near home and the coal has to stand a heavy transportation charge. It is the cost of power in money, rather than in heat units, which interests the consumer. When a low grade lignite, gasified in the producer, and applied in the gas engine, is found to generate as much power, ton for ton, as the highest grade of bituminous coal does when burned under the steam boiler, who shall say which is the best fuel? The trouble was rather with the method of application than with the material used.

The same line of thought extended to liquid fuels may indicate some comparisons between fuels which will be of interest. The extending use of gasoline in small combustion engines for automobiles, motor boats, and stationary service, has drawn attention to the fact that the supply of this high grade fuel is limited, and that the market price is certain to rise. When, however, as in the Diesel engine, it is found that ordinary mineral oils can be used to even greater efficiency, this limitation ceases to be of importance. Even the remote possibility of exhaustion of petroleum as a source of economical motive power serves only to draw attention to the fact that vegetable oils, capable of yearly production as a cultivated crop, are available. When it becomes desirable to look still further for a liquid fuel for power development, it is necessary only to be reminded that in the tarry residue remaining after coking there is fuel value enough to supply ample power, leaving the coke for efficient, smokeless heating and metallurgical service. Dr. Diesel has openly maintained that the tar production of Germany alone is sufficient to generate one and three-quarter millions of horsepower, running three hundred days ten hours each, all the year.

These facts indicate the extent to which many fuels have been misjudged simply because they have been regarded in comparison with an ancient standard, that of combustion in

a boiler furnace. The good fuel is that which provides cheap power at the point where it is wanted, and it is thus entirely possible that a low-grade fuel, considered from the heat-unit standard, may be a far better fuel than some much richer coal which, giving splendid results in a laboratory test furnace, has to bear the series of charges involved in deep mining, long-distance transport, losses from handling, and low efficiency in application.

The present is an age of standards, but the one difficulty about standards lies in their misuse to the extent to which, when established, they require a degree of permanency which acts as a barrier to further progress. When men learn that standards must be considered as but temporary, and that no hesitation should exist about abandoning old ones, however firmly established, as soon as newer and better ones appear, then standardization will cease to exert the paralyzing influence which has so often and so truthfully been attributed to it. The valuation of fuels is but a single example of the manner in which relative values may be wholly changed by the modification of an old-established standard, and many other instances might be cited. A guide which is usually safe is that of considering the ultimate result which is desired to be attained, remembering always that an efficient final result cannot be attained with a series which contains several inefficient elements. A few wasteful links in the chain will pull down the strength of the high-grade ones, and a better result will be attained with a moderate average in all. The story of power generation from heat is an example of this in a marked degree, since the great development in the formerly inefficient method of conversion of heat into mechanical energy is making the relative differences in thermal value of minor importance in comparison with questions of transport, handling, and similar items.

LAKE AND MOUNTAINS, ASHEVILLE, NORTH CAROLINA

HYDRO-ELECTRIC DEVELOPMENT IN WESTERN NORTH CAROLINA

By N. Buckner

THE development of the natural resources of the South has attracted the eyes of the world towards this section, so rich in natural resources as to astonish all who make even a cursory examination of them. When a full knowledge of these resources is had by the shrewd "men of millions," the growth of the Golden West will be dimmed by comparison with the wonderful growth of the South—the land of prolific opportunities and rapid development. The development of industries in the South is now the subject of lively comment throughout the entire country, due largely to the fact that the South is making use of its own natural resources, particularly that of the power in its waterfalls and streams.

In the State of North Carolina there are what might be termed three centres about which hydro-electric development activity has centered—Asheville, Charlotte and Raleigh. The development in the Asheville district has been accomplished by Asheville capitalists, with Captain W. T. Weaver as president of the corporation—the North Carolina Electrical Power Company—which company has and will continue to handle the power transmission features in the mountain region of Western North Carolina. Charlotte is the base of the hydro-electric development in the Piedmont region of the State, with Raleigh, the capital, in the central and eastern sections.

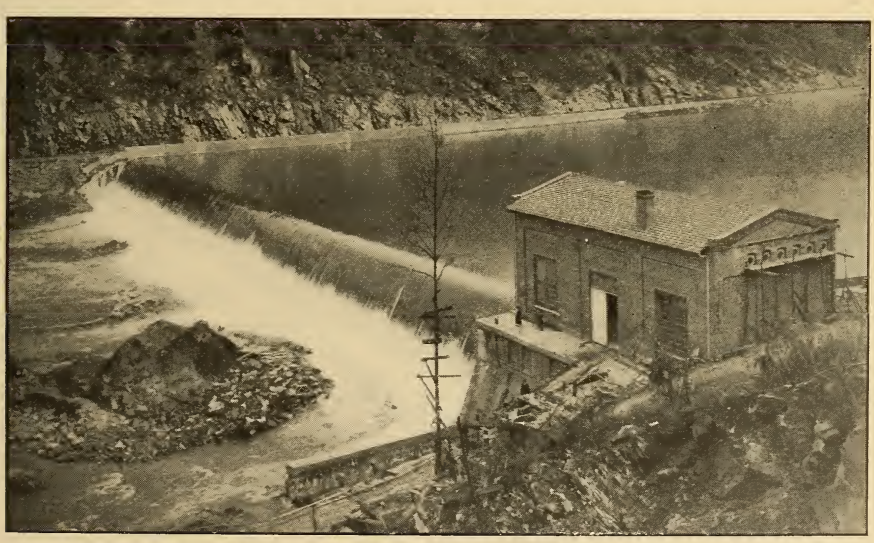
In the territory of which Asheville is the centre it is said there are more than a half million horse-power avail-

able from the streams and waterfalls, with only about 12,000 horse-power now developed and used for commercial purposes. Within a radius of 25 miles of this city there are now in operation seven hydro-electric plants—the Waynesville Light & Power Company, on the Pigeon river, which furnishes light and power for Waynesville, the county seat of Haywood county, adjoining Buncombe county to the west; the Hendersonville Light & Power Company, on Big Hungary creek, furnishing light and power for Hendersonville, the county seat of Henderson county, adjoining Buncombe county to the south; the Brevard Light & Power Company, in Transylvania county, furnishing light and power for Brevard; the Asheville Power & Light Company's plant on Hominy creek, Buncombe county, and the three plants of the North Carolina Electrical Power Company, on Ivy and French Broad rivers. This latter company also owns the Mountain Island power site and property on the French Broad river a few miles west of their Marshall plant No 3, which property is capable of the development of 10,000 horse-power. This company is strongly financed, and is prepared to supply the demands for increased electrical energy in this territory on comparatively short notice.

In this article the writer will briefly take up the developments of the North Carolina Electrical Power Company, describing more particularly the Marshall plant No. 3, recently placed in service. This company began its hydro-electrical developments in 1900 with the construction of Ivy Dam, known as plant No. 1, which was completed and placed in service the latter part of 1901, the current being delivered to the Asheville Electric Company for stepping down and delivery to the city of Asheville, its homes, business houses and industries. The Ivy dam is 120 feet long, 65 feet high, and built of masonry. The power house is of frame construction, 28 by 40

UPSTREAM VIEW, BELOW DAM. MARSHALL PLANT

MARSHALL PLANT OF THE NORTH CAROLINA ELECTRIC POWER CO., DURING CONSTRUCTION



WEST VIEW, MARSHALL PLANT, NORTH CAROLINA ELECTRIC POWER CO., ON FRENCH BROAD RIVER

MARSHALL PLANT, LOOKING EAST, SHOWING OVERFALL OF WATER

feet. The water is delivered to the wheels through iron pipe flumes 6 feet in diameter. The electrical equipment develops 750 horse-power, and is of the General Electric Company's design and manufacture.

The Weaver plant No. 2 was completed and placed in operation in May, 1904, and has a normal capacity of 3,200 horse-power. This plant is located on the French Broad river five miles north of Asheville. Its dam is built of masonry, 12 feet thick at the bottom, battered to 6 feet at top, 13 feet high and 606 feet in length. The wheels receive the water through a canal 3,800 feet in length, 960 feet of which is built of masonry, the remainder of earth embankment. The power station is of brick, 52 feet by 100 feet, with composite roof, and is equipped with a 20-ton traveling crane. The water-wheel equipment consists of a Hercules turbine, manufactured by the Holyoke Machinery Company, of Worcester, Mass., with two units horizontally connected to two 750-kilowatt generators, operating under a voltage of 6,600. One generator is of Westinghouse design, the other of Bullock design. In addition, there are two 56-kilowatt exciters directly connected to two 27-inch turbines, either exciter being capable of exciting the two generators. This plant No. 2 represents an expenditure of $325,000.

The third hydro-electric development of this company is the Marshall plant No. 3, located on the French Broad river about 25 miles northwest of Asheville. The normal development of this plant is 5,000 horse-power, and in round figures represents an expenditure of half a million dollars. It has been in service since January, 1912, and already a little more than fifty per cent. of its development is being utilized, which indicates the growth of the demand for electrical energy

DOWNSTREAM VIEW, DURING CONSTRUCTION. MARSHALL PLANT, ASHEVILLE, N. C.

in Asheville and the nearby territory.

In the construction of this plant it was necessary to raise and rebuild two and a half miles of track of the Southern Railway, the premier carrier of the South, which skirts the French Broad river at this point. The change in roadbed was accomplished at a cost of $75,000, required one year to complete, and all work was done without disturbing traffic, although there are daily operated over this piece of track an average of thirty to forty trains daily.

The dam is of cyclopean concrete construction, the large stones in some instances approximating five cubic yards. It is 540 feet in length, 30 feet high, 43 feet 9 inches wide at the base, and 11 feet at the top. In the construction of dam, foundations for building and the retaining wall

UPSTREAM VIEW ACROSS RIVER, MARSHALL PLANT, ASHEVILLE, N. C., DURING CONSTRUCTION

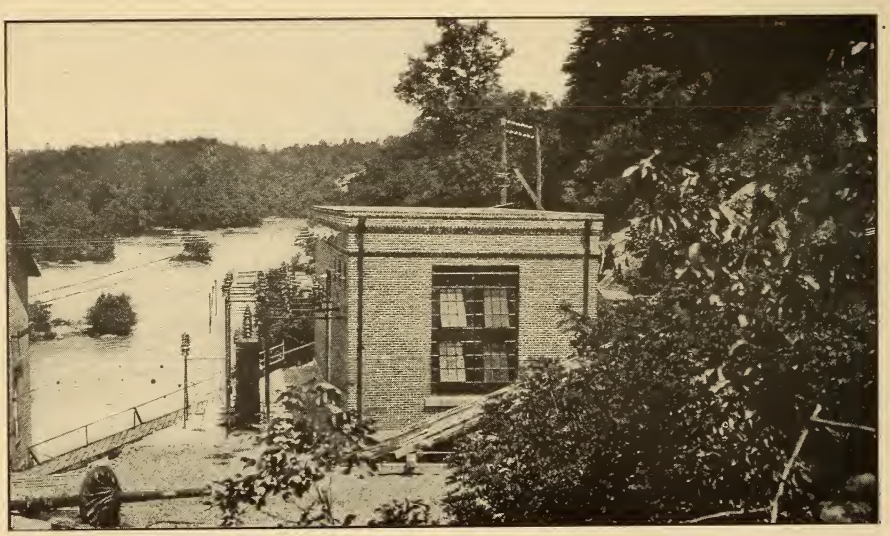
for protection of roadbed approximately 22,000 barrels of cement were used. The upstream side of the dam is perpendicular; the downstream face of the dam is curved, as shown in the view, in such a manner as to compel the water to flow evenly over its entire surface, thus preventing either compressed air or a vacuum between water and surface of dam, since it is generally conceded that such conditions on the downstream side is responsible for the trembling often felt in the vicinity of overfall dams.

There are two 7-foot gates in the dam next to the power house, which are operated hydraulically, and are opened and closed by an electrically-driven pump in the power house. The gates and cylinders are entirely submerged. The four penstock gates are among the largest cast-iron gates made, and each gate covers a clear opening of 18 feet by 7 feet 3 inches, and weighs 13 tons. They are operated in pairs by an electric motor.

The power house is of fireproof construction, 40 by 76 feet, built of concrete to the floor line, and from that point up of brick. Windows are steel frames with prismatic glass. Distance from floor to eaves is 31 feet; from bottom of foundation to comb of roof is 100 feet. A 50-ton traveling crane, electrically operated, extends the entire length of the building.

The electrical equipment is composed of two 1,875-kilowatt Westinghouse 3-phase, 60-cycle, alternating-current generators, vertical, with exciters located on top of the generators; generators operate at 6,600 volts and 133 revolutions per minute. Each is directly coupled to two turbines made by the I. P. Morris Company. The entire control of the plant is from the switchboard, all gates, switches, motors and valves being electrically operated.

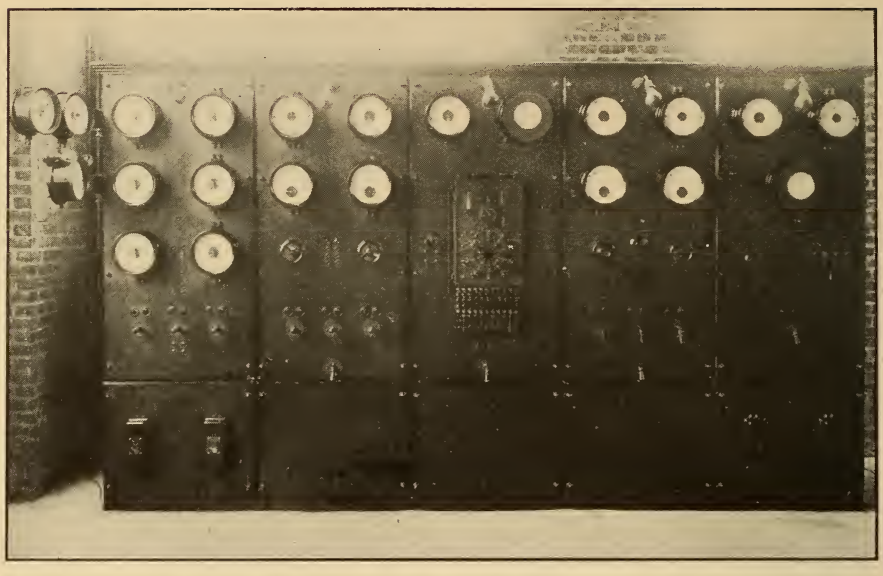
The power is generated and distributed at 6,600 volts, the tie lines between the three plants operating at 66,000 volts. Duplicate power lines have been built on private right of way, one on the west side and the other on the east side of the river, to the Weaver plant No. 2 of this company, on the French Broad river, five miles northwest of Asheville, where is located the sub-station for the distribution of the power to Asheville, Canton, Marshall, Weaver-



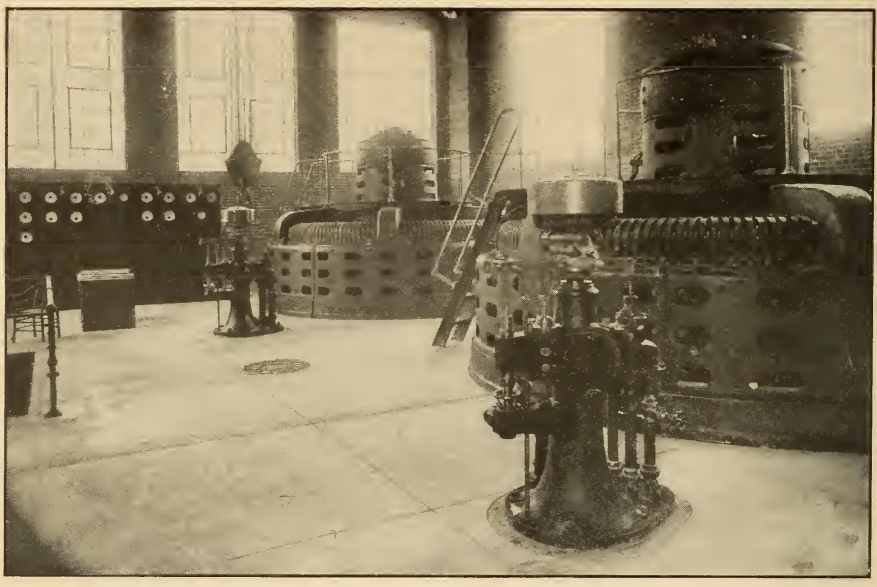
TIE-IN SUB-STATION, WEAVER PLANT, ASHEVILLE, N. C. SHOWING 66,000-VOLT LINE

UPSTREAM VIEW OF DAM, WEAVER PLANT, NORTH CAROLINA POWER CO., ASHEVILLE, N. C.

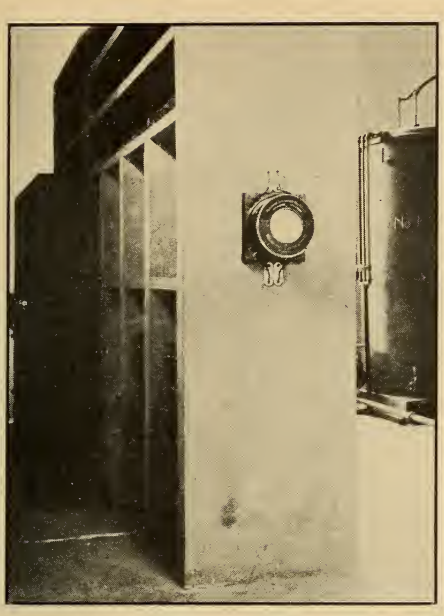
WEAVER PLANT, ASHEVILLE, N. C., SHOWING TIE-IN SUB-STATION, POWER HOUSE AND FOREBAY



SWITCHBOARD BUILT BY WESTINGHOUSE ELECTRIC AND MANUFACTURING CO. FOR MARSHALL PLANT



GENERATOR ROOM SHOWING WESTINGHOUSE THREE-PHASE ALTERNATORS



INTERIOR WEAVER SUB-STATION, BARRIER STRUCTURE

ville and Biltmore. The power is transmitted from the three main stations over about 80 miles of transmission lines. A ring bus-bar is used, and all wiring is in cable or conduit. The wires are multicolored, the color signifying the use and origin, as red braid is always neutral, common or negative, depending upon circuit; white is invariably an instrument wire from phase "a," black an instrument wire from phase "c," or positive depending upon the circuit. The back of the switchboard is similarly arranged, so that connecting it up merely resolved itself into matching colors at opposite cable ends. The large switches are electrically operated, and the relays that handle the current in the solenoids are shown in the accompanying illustration of the switchboard.

The potential maintained at the Asheville centre of distribution is practically constant, without regard to the load changes, such condition being obtained through careful adjustment of several Tirrill regulators. No feeder regulators are employed. The frequency of the circuits is about as constant as the potential, the only variable factors on the circuits being the loads and power factors. As in other similarly connected plants, the power factor varies through wide ranges where a constant potential is maintained; however, by shifting the wattless component from one generating station to another an average temperature of all machinery is easily obtained. The plants of this company are unique in operation and somewhat different from the ordinary.

This Marshall plant No. 3 was designed by Charles E. Waddell, member American Society of Civil Engineers, also member American Institute Electrical Engineers, Asheville, N. C. Charles Folsom is resident engineer.

TRANSMISSION POLE STRUCTURE. NORTH CAROLINA ELECTRICAL POWER CO., ASHEVILLE, N. C.

WATER-POWER DEVELOPMENT IN THE SOUTH

By J. A. Switzer

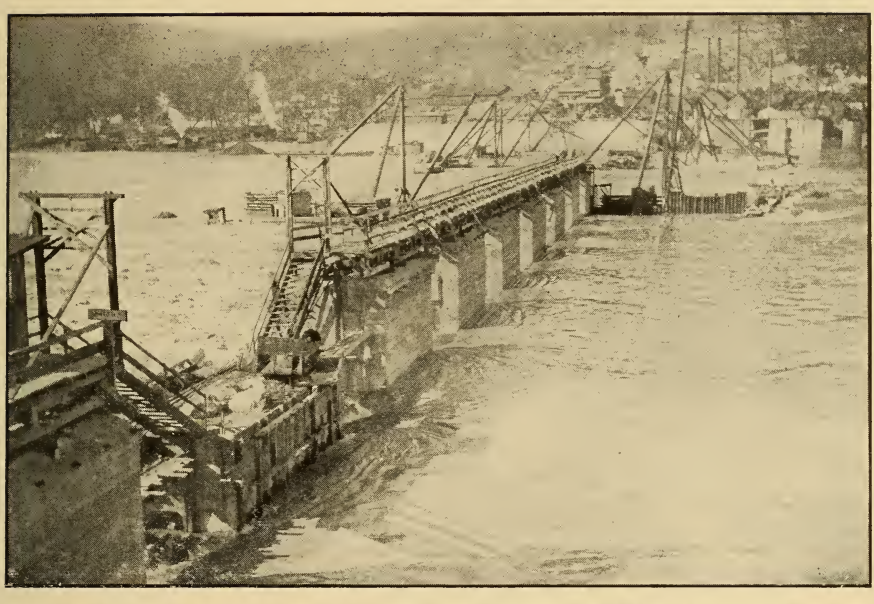
(Concluded from the June issue)

IN the last number of this magazine there was given some account of the extent to which the natural hydraulic power resources of the Appalachian region is being developed, especially in the Piedmont district of the Carolinas. These included the work of the Southern Power Company, with its developments on the Catawba and Broad Rivers; of the Rockingham Power Company on the Peedee River; the plant of the Central Georgia Power Company, on the Ocmulgee River; and the developments of corporations in Alabama and in Tennessee. Especially full accounts were given of the plans for the development of the Tennessee River at Hale's Bar, with a map and general description of the manner in which more than 50,000 horse-power is to be developed and material improvement in navigation effected.

The preceding article discusses the arrangement of the foundation of the dam, and its relation to the power house and surrounding country.

The dam, 40 feet high, measured from low-water level, is from 45 to 65 feet high above foundation rock. The spillway is 1,200 feet long; on the west it terminates in a lock and on the east in the power house,

VIEW OF PARTIALLY COMPLETED HALES BAR DAM AND POWER HOUSE, FROM WEST, AS THEY APPEARED IN SEPTEMBER, 1911



VIEW OF DAM AT HALES BAR, DECEMBER 28, 1911, SHOWING THE EFFECT OF A HEAVY FLOOD

VIEW WITHIN THE COFFERDAM, HALES BAR, JUST WEST OF CENTER OF RIVER, SHOWING SECTIONS OF FOUNDATION WHICH WERE BUILT BY THE CAISSON METHOD

which itself forms part of the dam. The power house is 350 feet long, and still beyond this is an earth dam, about 800 feet in length, having a concrete corewall, and protected by riprap. The over-all length of the entire structure is, therefore, approximately 2,500 feet.

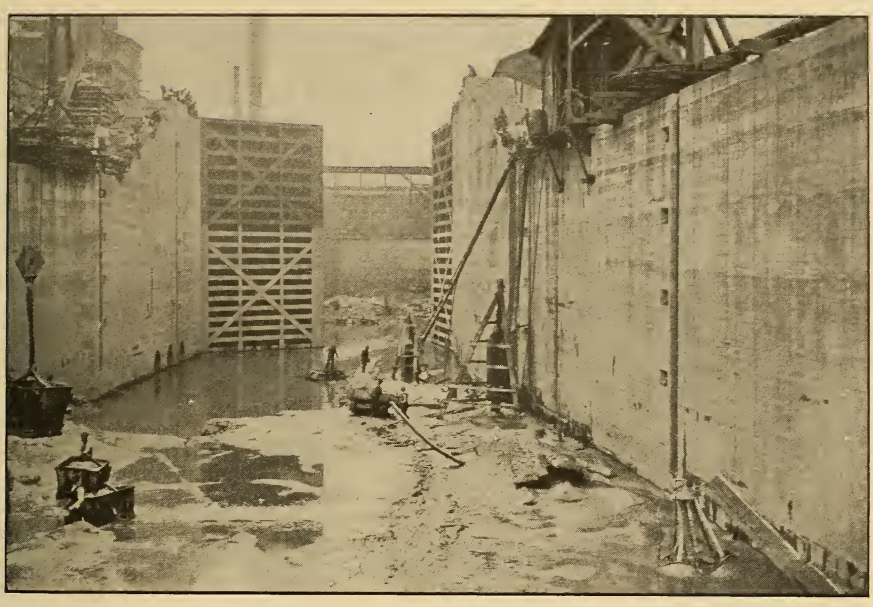
The lock and the power house are now completed. Since the Tennessee is a navigable river, title to the power site necessarily inheres in the United States, the company having been granted a 99-year franchise. For the same reason, the entire work of construction, as far as regards stability, is subject to the inspection and approval of government engineers. The lock and dam are built under their active supervision. The lock chamber is 60 feet wide and 312 feet long between quoins; and the most interesting fact concerning it is that nowhere else in the world is there a single lift lock as high. The downstream gates are 58 feet high and the lock walls 59 feet. These great steel gates will be operated by electric motors, as will also be the gate valves controlling the flow of water into the lock and out of it through the two large culverts, provided with ten outlets each for this purpose.

The power house (built of reinforced concrete) is an imposing structure. The architectural treatment has been admirable, but there was no straining for effect. Utility was the keynote of the design, and hence the building is essentially artistic. The accompanying photographs give an excellent idea of its appearance. The view taken from the tail-race shows the power house proper to be the left-hand section of the building and the transformer house the right-hand. The turbines are mounted in seven bays, and these are indicated by the seven arches opening into the tail race. In each bay two separate units of power development are installed. Each unit consists of three turbines and the generator, mounted on a vertical shaft and supported upon an oil thrust bearing. At all ordinary stages of the river the two lower turbines of the unit will develop the full rated horse-power and the uppermost will not receive water. But as the river rises tailwater will rise more rapidly than headwater, resulting in a considerable diminution of the effective head on the plant. To meet this condition and offset it, the uppermost turbine is provided, and this turbine is so placed that as the crippling stage of flood is reached it begins to take water, thus developing power enough to supplement the diminishing amount which the lower wheels can transform, and so maintaining the plant capacity at full rating up to such flood stages as occur only very rarely. The accompanying table is of interest as ilustrating this discussion:

At the present writing the turbines are all in place and the generators in process of erection. The transformers are in place and the steel tower transmission line to Chattanooga is built. All electrical equipment was furnished by the General Electric Company, the turbines being the Morgan-Smith type. The dam is

TABLE SHOWING RELATION OF RIVER HORSE-POWER TO THE STAGE OF THE RIVER.

Chattanooga Gauge Reading.	River Discharge Cubic Feet per Second.	Elevation Tail Water.	Elevation Head Water.	Head on Wheels.	Power in H. P. of Current on Switchboard. Avg. 14 Hours.	Avg. 10 Hours.
0.1	6,700	598.5	638.00	39.50	16,800	40,000
0.5	7,900	598.7	638.00	39.30	16,700	42,000
1.0	9,400	599.0	638.00	39.00	16,600	52,000
2.0	13,000	600.2	638.45	38.25	30,500	58,800
3.0	17,800	601.0	638.75	37.75	53,500	58,800
5.0	27,000	602.7	639.50	36.80	58,800	58,800
10.0	53,400	607.0	641.50	34.50	58,800	58,800
15.0	84,000	611.2	643.40	32.20	58,800	58,800
20.0	120,000	615.5	645.33	29.83	58,800	58,800
25.0	159,000	619.7	647.25	27.55	58,800	58,800
35.0	249,000	628.2	651.10	22.90	46,800	46,800
40.0	295,000	632.5	652.83	20.33	36,500	36,500



LOOKING INTO THE LOCK CHAMBER, HALES BAR. THE GREAT STEEL GATES ARE 58 FEET HIGH, AND THIS WILL BE THE HIGHEST SINGLE-LIFT LOCK IN THE WORLD

probably three-quarters complete, and should be finished within the twelve months and power turned on.

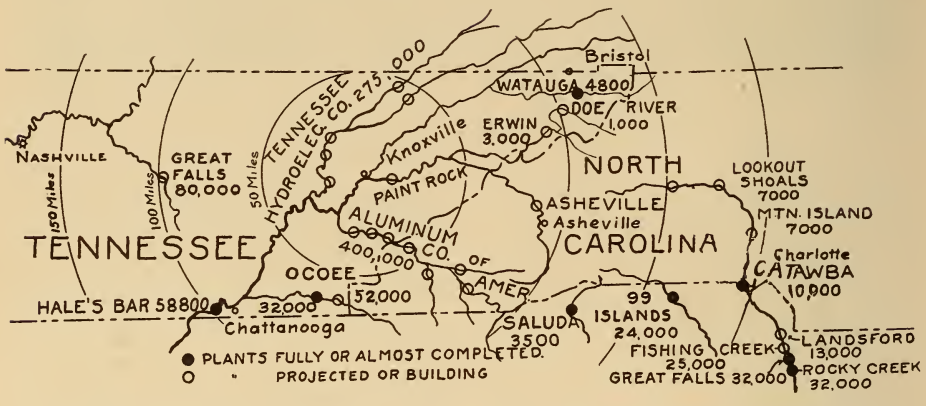
The chief engineer on this work is Mr. John Bogart, of New York City; the resident engineer, Mr. George F. Rowell, and the electrical engineer, Mr. B. T. Burt, of Chattanooga; and it is to the second gentleman that the author is indebted for the photographs reproduced in this article showing portions of this striking hydroelectric development at Hale's Bar.

Another Hydro-Electric development in this section is the Tennessee Hydro-Electric Company, incorporated with the following officers: President J. P. Paull, of Pittsburg, Pa.; vice-president and general counsel, James B. Cox, United States District Attorney, of Knoxville, Tenn.; treasurer and chief engineer, F. M. Butler, of New Castle, Pa.; secretary, J. R. Cox. The company proposes to develop all of the available power of the Clinch and Powell rivers in Tennessee and Virginia. Their plans contemplate the building of five dams at a total outlay of $20,000,000, developing something like 275,000 horsepower, their rights covering the entire length of both the rivers mentioned.

Great as are all of these developments, there is still another now proposed which, when completed, will exceed any other present single system of water-power development within the border of the United States. It is that of the Aluminum Company of America.

For some months past the Aluminum Company has been busy acquiring title to all the power rights and riparian privileges on the Little Tennessee River, from Franklin, N. C., a distance of 65 miles, to a point 20 miles south of Maryville, Tenn., where the river finally emerges from the Unaka Mountains, and exchanges the exuberant vigor of a mountain stream for the more sedate habit of a mature river. In addition to this the company has acquired the tributary streams—the Cheoah, the Tuckaseegee and the Natahala Rivers. Complete surveys of this water-power domain have been made, and the sites

of power-houses and storage reservoirs have been quite definitely determined. The sketch map shows the extent of these holdings, and the sketch profile of the Little Tennessee (by no means accurate) shows in a very general way the nature of the proposed development. The ultimate plan contemplates the construction of dams, one beyond another, so placed that each will back water nearly or quite up to the toe of the dam next above it. Some of these dams, owing to the steep and narrow character of parts of the river-bed, will impound but small quantities of water; while others more favorably situated for storage purposes will form lakes of large ex-



MAP SHOWING HYDRAULIC DEVELOPMENT WITHIN A RADIUS OF 150 MILES FROM KNOXVILLE, TENN.

tent. For instance, at one point on the Cheoah River a dam 135 feet high will impound about three and a half billion cubic feet of water. There are a number of fortunate reservoir sites; and the ultimate development now projected will not only utilize practically all of the fall of the streams (about 1,200 feet on the Little Tennessee River alone), but will to a very large extent conserve the flood waters of spring to spread them over the dry months of summer, and thus develop in an ideal manner the total power of all the annual stream runoff.

This power will exceed 400,000 horse-power.

The Aluminum Company, by purchasing the stock of the Knoxville Water and Electric Power Company, has acquired a franchise for furnishing light and power in Knoxville. However, furnishing light and power in Knoxville will merely be pastime for the Aluminum Company; for the serious purpose of the company is to erect reduction works for the production of aluminum. Aluminum is made from the mineral bauxite. This the company now mines in Missouri and Arkansas and ships to the concentration plant located at East St. Louis. Five tons of ore produce two tons of concentrate. The concentrate is then shipped either to Niagara Falls or to Massina, N. Y., where are situated the electrical reduction furnaces of the company. Two tons of the concentrate yield one ton of pure aluminum, and this metal is then sent to the company's works at New Kensington, Pa., where finally it is fabricated into wire and the aluminum products of commerce.

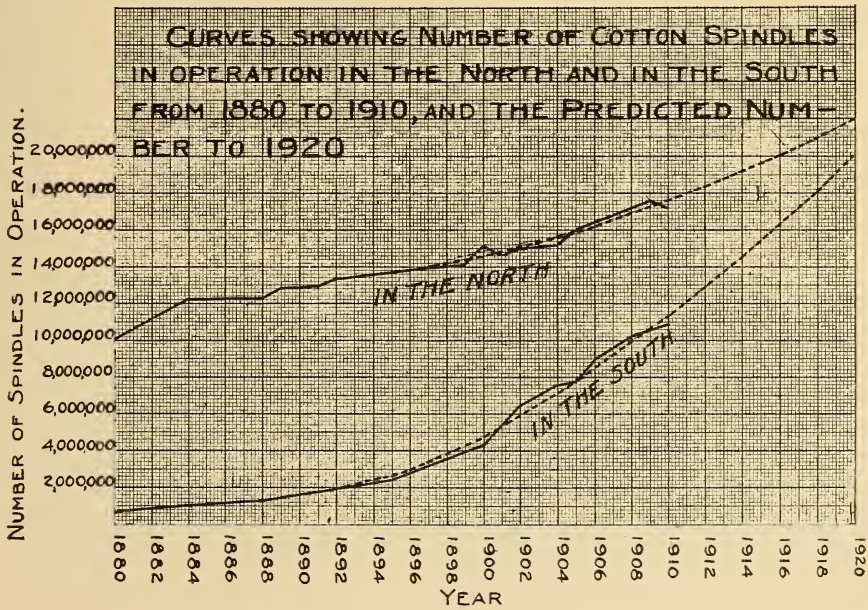
The productive capacity of the company's two reduction plants having become wholly inadequate to supply the market, it is the expectation that a new plant will shortly be built at or near Knoxville; and as each succeeding unit of power development on the Little Tennessee River is completed, the capacity of the reduction works will be correspondingly enlarged. It

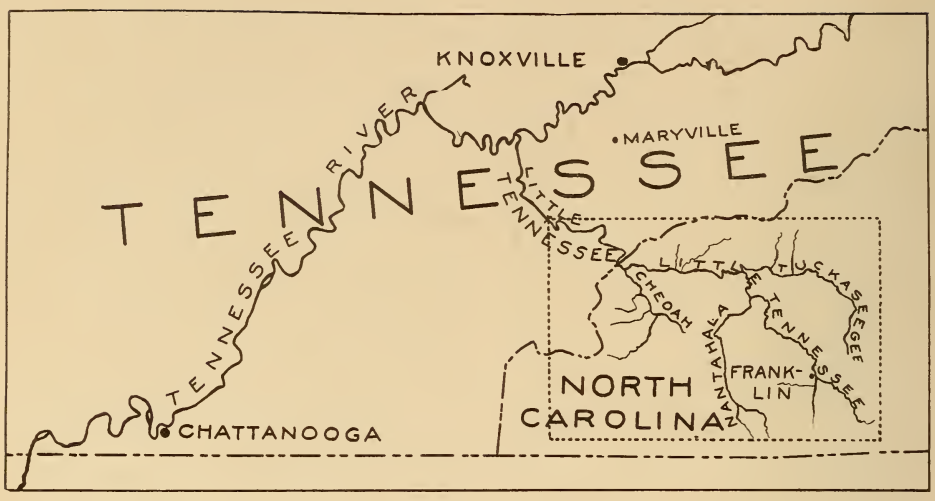
is said that the first development will be of such size as to give employment to about 5,000 men.

Now, although the present article does not claim to furnish a complete list of the great water-power developments in the South, either actualized or in process, or in prospect, enough has surely been said to show the intensity with which this line of work is being carried forward and to indicate what the remaining years of this decade are certain to produce. The water-power resources of the southern Appalachian region are simply enormous. The United States Geological Survey places its estimate at 7,000,000 horse-power—a quantity too great for comprehension.

While the developments thus far effected constitute but a small percentage of the water-powers awaiting their turn to be harnessed, nevertheless they are already appreciably affecting the industrial growth of the South, and in the years to come their influence will be progressively greater and greater. Already they are a factor in the economic advance of the southern Appalachian region. How pronounced is this advance? How great is it likely to become in the near future? Merely to indicate the answer to these questions—rather than to attempt categorically to answer them—let us consider the cotton industry. In the year 1880 the number of spindles in operation was in the North 10,092,000 and in the South 561,000. The South operated 5.3 per cent. of the whole. In 1890 the South operated 10.9 per cent. of the whole; in 1900, 22.3 per cent.; in 1910, 38.5 per cent.

What of the year 1920? In order to make a prediction for 1920 the actual number of spindles in operation in each section on September 1 of each year from 1880 to 1910 has been plotted (see diagram here shown). And then, to venture a prediction, the curves have been projected forward to 1920, on the assumption that the economic laws which have governed the growth of the cotton industry for the past twenty years will hold for the eight years to come. Then in 1920 the South will manufacture 47 per cent. of the cotton goods of the country. Or, to put the matter in a manner still more striking, in 1910 the South oper-





PORTION WITHIN DOTTED RECTANGLE SHOWS EXTENT OF THE WATER POWER HOLDING OF THE ALUMINUM COMPANY

ated eleven million spindles; in 1920 it will operate twenty million.

It is believed that the growth of the cotton industry may be taken as more or less nearly typical of business expansion generally throughout the South. And if this be granted, there are two ways in which this discussion relates to the subject of water-power development. First, the industrial expansion already attained is due, in a measure, to the cheapness of water-power already developed. Second, the further industrial expansion will react upon and greatly stimulate the further development of the remaining latent water-powers.

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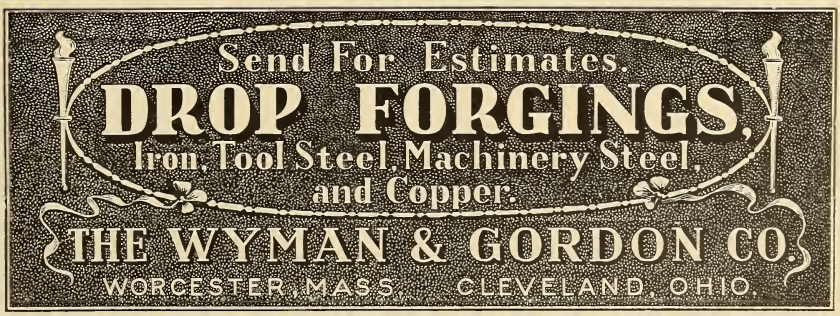
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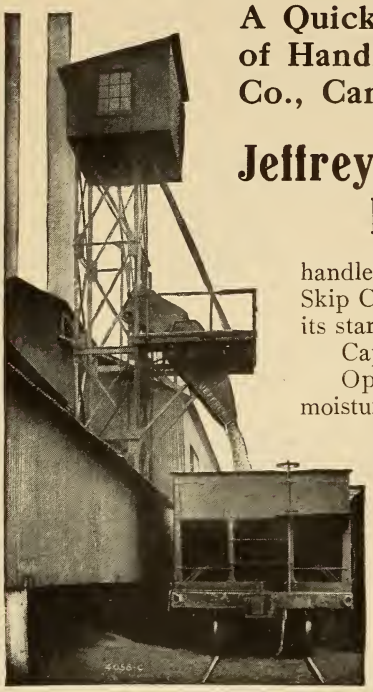

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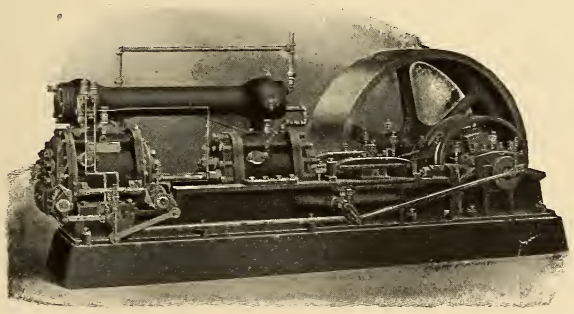

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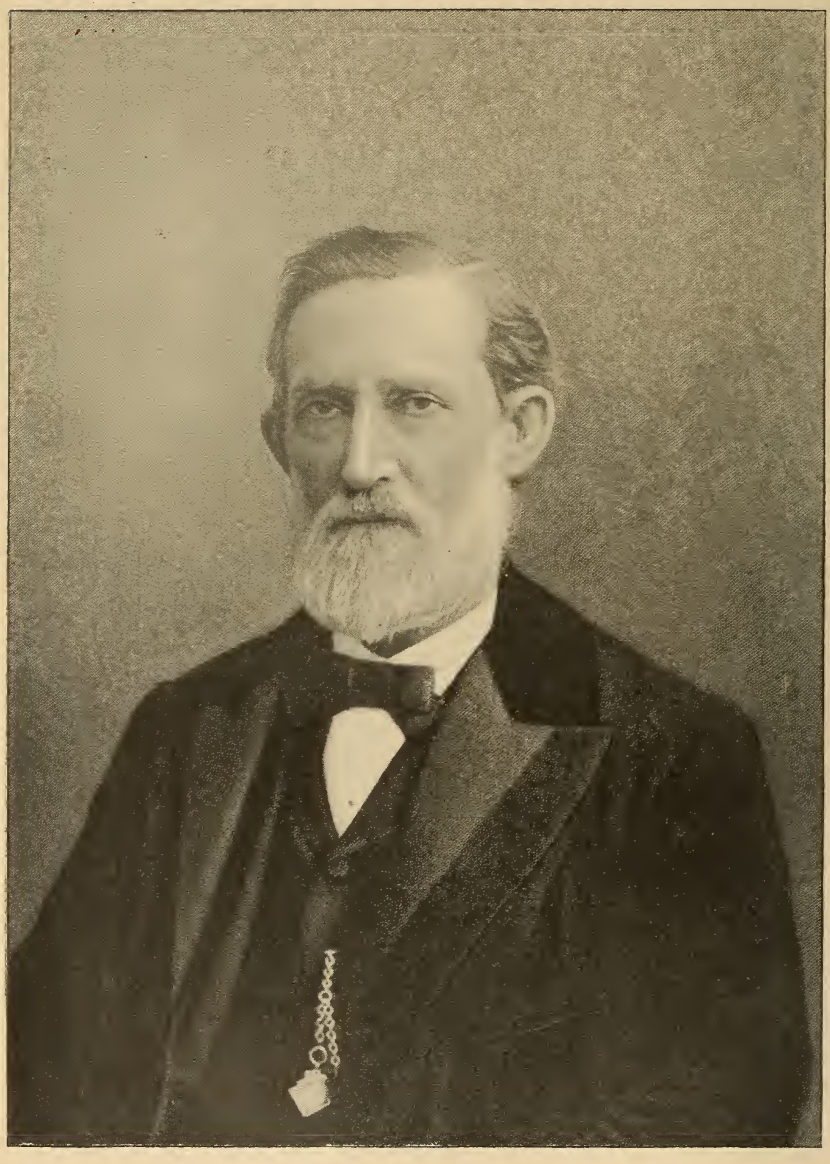
It has been well understood for a long time that the progress of an industry may be materially aided by the work of associations devoted to the collection and publication of reliable and unbiased statistical and general information concerning the special department of work concerned. Among the important organizations of this kind in the United States none has been more effective and useful than the American Iron and Steel Association, and much of the efficiency of this organization has been due to the tireless industry of Mr. James M. Swank, who for nearly forty years has been its secretary, general manager and vice-president.

Mr. Swank was born in Westmoreland county, Pennsylvania, in 1832, and, after an education at Elders Ridge Academy and at Jefferson College, Pennsylvania, he entered upon journalistic work, and for eleven years was editor and publisher of the Johnstown *Tribune*. During 1871-1872 he was chief clerk of the United States Department of Agriculture, and in 1873 he became secretary of the American Iron and Steel Association, of which he has been vice-president and general manager since 1885.

In addition to the important work of editing the publications of the association, Mr. Swank is the author of a History of the Department of Agriculture; Iron Making and Coal Mining in Pennsylvania; History of the Manufacture of Iron in All Ages; also several publications relating to history of Pennsylvania, and numerous papers upon tariff questions. Mr. Swank has received the honorary degree of Doctor of Philosophy from Washington and Jefferson College, Pennsylvania, and of Doctor of Laws from Temple University, Philadelphia.



JAMES M. SWANK

American Iron and Steel Association

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XLII AUGUST, 1912 NO. 2

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STEELS MADE IN THE ELECTRIC FURNACE

By E. F. Lake

IT is only about five eyars since steel was made in electric furnaces for commercial purposes and sold in the open market. The Electro-Steel Works at Remscheid-Hasten, Germany, was the first to enter that field. The electric furnace steel is the equal of crucible steel in every particular, and superior to it in some of its properties. That it is cheaper than crucible steel will mean that for most purposes the electric steels will take the place of crucible steels in the future. After the lapse of these five years many different companies have started manufacturing steels in electric furnaces. These are situated principally in Germany, France and the United States, England having only a few furnaces in operation.

The development of this process has been slow, and, like many other things, it has stretched out through a century or more before being placed on a practical commercial basis.

The first experiments along this line, and probably the first use made of electricity for obtaining high temperatures in furnaces, were performed by Sir Humphry Davy in the early part of the last century. In conducting these experiments, he used a large primary battery, composed of plates of copper and zinc in an acid solution. The battery was presented by the nation to him or the Royal Institution which he represented, as a token of esteem for his scientific researches and as an aid to further investigations.

Several patents were issued on the use of electricity for metallurgical purposes from 1840 to 1850, but no practical results could be obtained until the electric dynamo was made a commercial success.

About 1879 Sir William Siemens produced an electric furnace for steel melting. This furnace, however, was only an experimental one and consequently small. In the latter part of a crucible he placed two lateral and inclined carbon electrodes. Steel scrap was charged in the crucible and the current turned on to form an electric arc between the electrodes. The heat partly radiated directly from the arc and partly from the cover and thus brought the steel to a state of fusion. This is practically the principle of the Stassano furnace as used to-day in Turin, Italy.

Later, Siemens passed a water-cooled electrode through the bottom of the crucible and brought it into contact with the charge. For the other electrode, a vertical carbon rod was attached to the furnace and regulated by a sort of differential gear. With this apparatus an arc was struck

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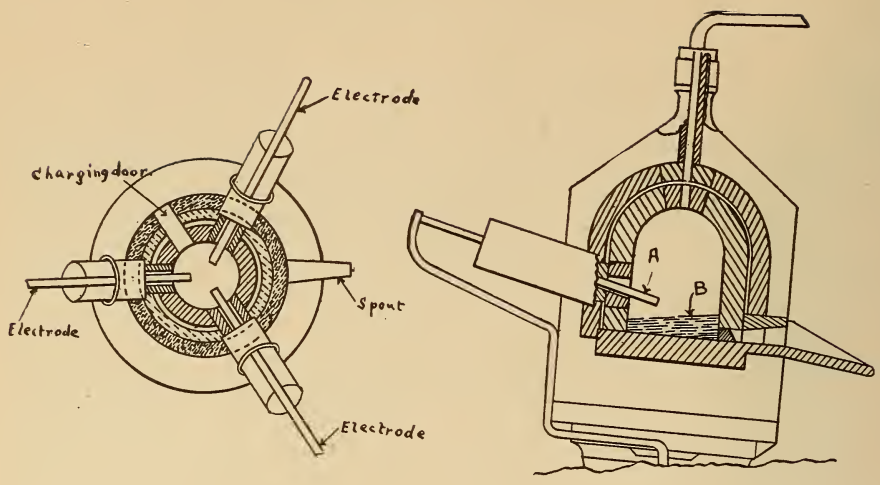


FIG. 1.—TRANSVERSE AND VERTICAL SECTIONS OF STASSANO ELECTRIC STEEL FURNACE

between the charge and the carbon rod. This resembles the basic principle on which the Girod furnace, now used at Ugine, France, is based.

Mr. Z. de Ferranti built an induction furnace in 1886, probably the first electric furnace of this type that was constructed. It was never operated, however, owing to his not being able to obtain the proper form of electrical motor. E. Colby in the United States, Henry Moissan in France, and Bullier, Willson and Acheson, as well as others, next developed electric furnaces for making calcium-carbide, carborundum and other materials which required high temperatures for their production. From these developments and the improvements that were made from time to time, the commercially practical furnaces of the present day have been developed. Dr. Heroult, of France, and Major Ernest Stassano, of Italy, have worked along this line for many years, and it is only recently that their efforts have become commercially successful.

Electric furnaces may be placed in three classes. One is the type which delivers the heat to the metal by radiation from an arc, struck between two or more electrodes placed over the top of the bath, as illustrated by the Stassano furnace shown in Fig. 1. In this furnace the electrodes are shown at *A* and the metal bath at *B*.

The second type is one in which the arc is struck between the metal, being melted and refined, and an electrode. In this the electrode is suspended about two inches above the molten metal and barely touches the slag. This type is well represented by the Heroult, shown in Fig. 2. In this, *C, C* are the electrodes, *D* the slag, *E* the molten metal and *F* the basic hearth.

The third type is the induction furnace. This consists of a closed magnet core, with two or three limbs, one of which passed through the center of an annular hearth. Co-axial to the bath an energizing coil is placed on this member. Some place this coil outside and around the hearth; others, above and beneath the hearth, and still others place the coil in the center as near the secondary as the heat will allow. Several different makes of this type of furnace are prominent. A single-phase Rochling-Rodenhauser furnace, as shown in detail in Fig. 3, and a 3-phase in Fig. 4. A general idea of the appearance of these can be obtained from Fig. 6.

The Girod furnace is a combination of the last two types—that is, of the induction and arc furnaces. One of

the 12½-ton furnaces of this type is shown in Fig. 7, as it is pouring the charge into the ladle. This has been in practical use for the manufacture of steel for several years at Ugine, France. The details of its construction are shown in Fig. 8. A smaller furnace of this same type that has been used for some time in Aarne, Switzerland, for producing steel castings is shown in Fig. 9 and its details in Fig. 10.

It is not the intention, however, to enter into a discussion of the different types or models of furnaces or to describe them in detail, but rather to treat of the steels that are being produced in them. All of the furnaces make steels of practically the same qualities or kinds, and that have the same chemical and physical characteristics. In so far as the actual making or refining of the steel is concerned, the electric furnaces all use the same methods, and the choice between the various kinds is based on the cost of up-keep and operating expenses. This varies for different classes of work and under different local conditions.

One of the main features of the electric furnace, and probably the secret of its making better quality steel than other processes, is due to the fact that there is more chance to get the steel right in the furnace. In the open hearth furnace only one slag, which is an oxidizing one, can be used. In the crucible furnace the materials must be right when they are charged, as they cannot be purified in the crucible. In the Bessemer converter only a low grade of steel can be made, as the impurities are blown out and the bath is afterwards recarburized.

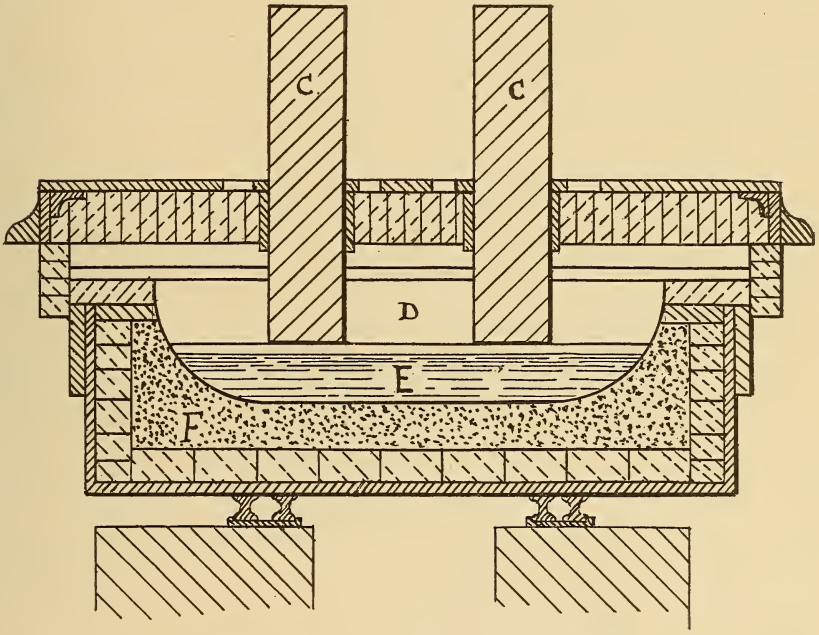


FIG. 2.—SECTION OF THE HEROULT ELECTRIC FURNACE

In the electric furnace, however, a first or oxidized slag can be used and the bath made as nearly right with this as with the other processes. This may then be removed and replaced with a slag that is composed entirely of lime. This is carbonized to a certain extent as soon as it is softened in the furnace, and the combination of carbon and lime forms a certain amount of calcium carbide, which has a reducing influence, rather than an oxidizing one. Under this slag the bath can be properly oxidized before

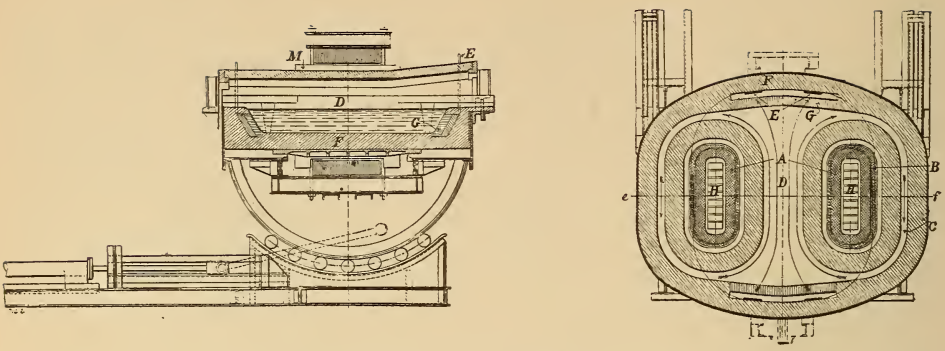


FIG. 3.—SINGLE-PHASE COMBINATION ELECTRIC STEEL FURNACE

it is turned into the ladle and the phosphorus and sulphur reduced to a mimimum. Thus the occluded gases, which are now considered very injurious elements in steels, can be reduced to a lower percentage than is possible in steels made by any of the other processes. With these removed, the metal will show greatly increased dynamic properties and the static strengths will also be increased.

While electricity is used only as a source of heat, it does not simultaneously introduce oxygen in the furnace, and this gives it a great advantage over other sources of heat. The purifying of the metal is performed by methods that have been in use for considerable time in the blast furnace, puddling, Bessemer, and open-hearth processes. In the Bessemer process, large amounts of oxygen are introduced by means of the blast that generates the heat. Much oxygen is brought into the puddling and open-hearth furnaces by the flame that supplies the heat, and this often makes them violently oxidizing when the atmosphere in them is thought to be reducing. This freedom from oxygen is the chief reason for the advantage the electric furnace has over other older processes.

To purify the bath of metal in the electric furnace, the carbon, silicon and phosphorus are oxidized into carbonic oxide, silica and phosphoric acid, by means of the atmospheric oxygen forming iron oxide in the process itself, or by adding iron ore to form the iron oxide. The former action takes place in the Bessemer and open-hearth processes and the latter method is used in the puddling and open-hearth furnaces. The sulphur is partly removed by distributing itself between the metal and slag in the form of sulphide of manganese, and partly by passing wholly into the slag in the form of sulphide of calcium. The first of these reactions takes place in the puddling and basic Bessemer processes and the latter in the blast furnace. Thus it will be seen that the electric furnace combines the good purifying qualities of all the older processes.

TABLE I.—RESULT OF ANALYSES FOR SULPHUR ON 1,000 CONSECUTIVE CHARGES FROM FURNACES AT ELECTRIC STEEL WORKS

Number of Charges.	Percentage of Sulphur Not Over	
88	.001	Minimum sulphur content, .010 per cent. in 743 charges.
5	.002	
14	.003	
29	.004	
50	.005	
82	.006	
100	.007	
168	.008	
99	.009	
108	.010	
67	.011	
64	.012	Minimum sulphur content, .015 per cent. in 958 charges.
35	.013	
29	.014	
20	.015	
11	.016	
14	.017	
6	.018	
1	.019	
2	.020	
2	.021	
2	.022	
2	.023	
1	.025	
1	.026	
1,000 charges.		

In the older processes it is very difficult to reduce sulphur below .025 per

TABLE 2.—ANALYSIS OF DIFFERENT KINDS OF STEEL MADE IN GIROD FURNACE AT UGINE, FRANCE

Kind of Steel.	Percentage of— Carbon.	Manganese.	Silicon.	Phosphorus.	Sulphur.	Nickel.	Chromium.	Other.
Very soft	.079	.205	.106	.012	.015	...	...	
Soft	.236	.431	.180	.010	.012	...	...	
Medium soft	.283	.430	.208	.010	.014	...	...	
Medium	.388	.342	.155	.009	.011	...	...	
Medium hard	.463	.463	.204	.016	.010	...	...	
Hard	.596	.302	.198	.005	.017	...	...	
Very hard	1.010	.306	.219	.009	.008	...	...	
Tool	1.223	.224	.168	.010	.011	...	0.32	
Tool	1.251	.258	.176	.008	.010	.049	1.21	
Tool	1.277	.130	.230	.006	.009	...	0.24	
Very hard tool	1.474	.264	.119	.007	.015	...	...	
2 % nickel	.076	.101	.099	.010	.014	2.12	...	
3 % nickel, soft	.060	.209	.123	.007	.013	3.47	...	
3 % nickel, hard	.364	.435	.144	.015	.012	3.41	...	
5 % nickel, soft	.134	.375	.148	.013	.016	5.25	...	
5 % nickel, medium	.250	.414	.157	.015	.010	5.08	...	
Chrome nickel	.420	.500	.199	.009	.010	2.53	0.77	
High speed	.689	.096	.029	.009	.012	...	6.07	25.82 W. 0.46 Mo.

cent., and lower than .025 per cent. is seldom obtained in America. Phosphorus, likewise, is seldom reduced below .02 per cent. The difference in methods, however, allows the electric furnace process to reduce these two elements to a very trifling quantity.

The low sulphur content that it is possible to obtain in the commercial production of steel is shown in Table 1. This gives the sulphur analyses of 1,000 consecutive charges made in a

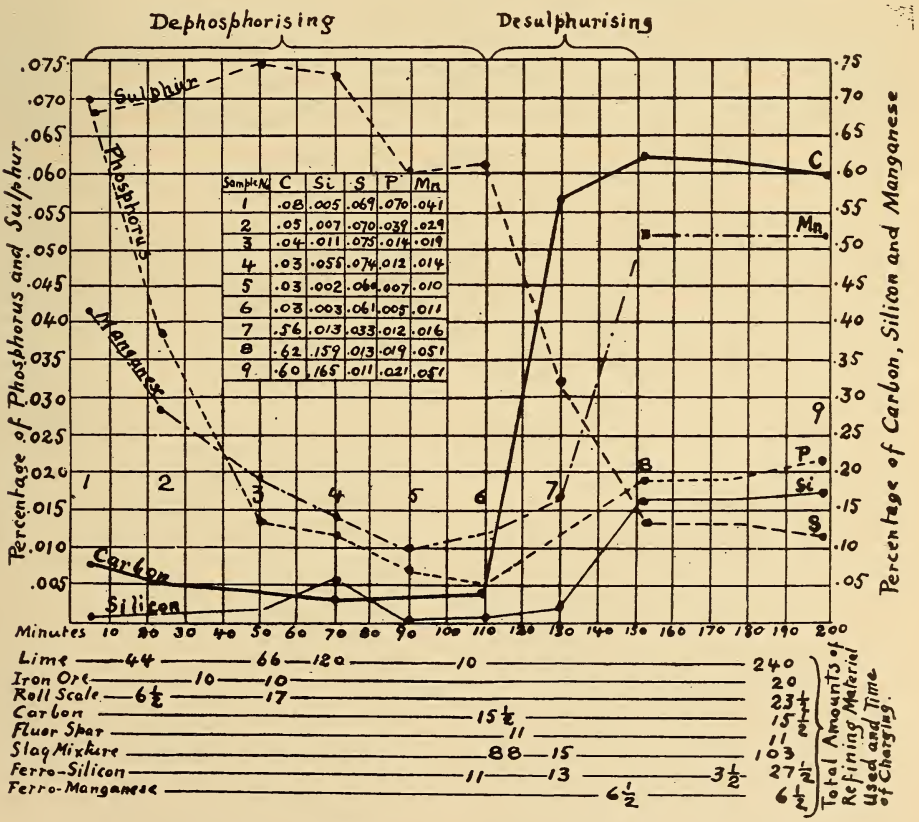
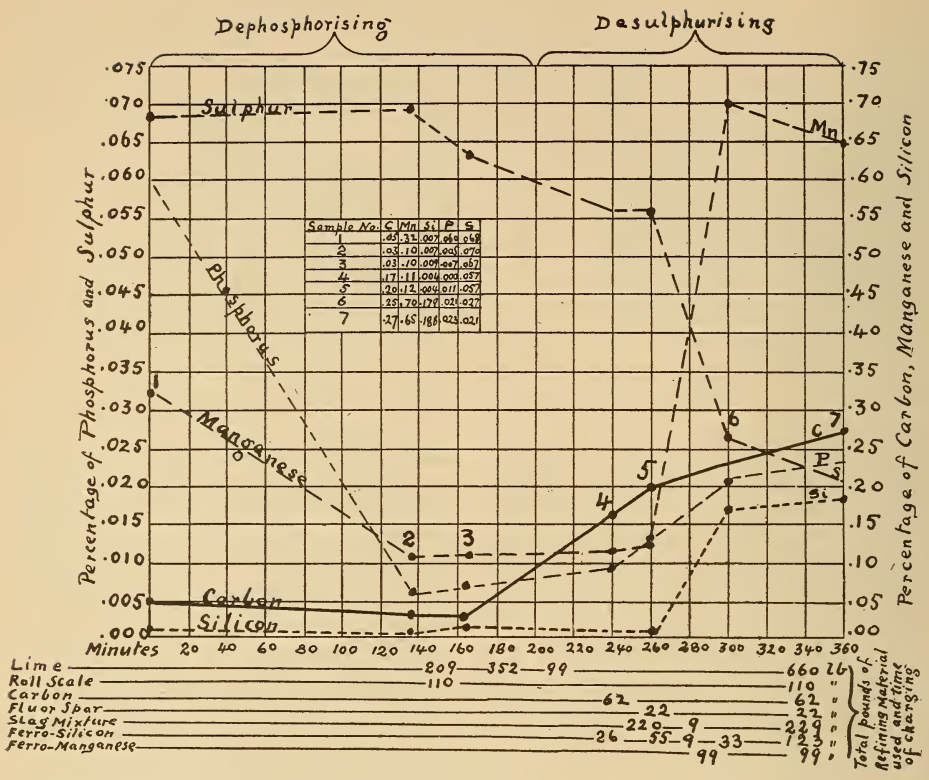


DIAGRAM 1.—PROGRESS OF REFINING OPERATIONS IN 2-TON, THREE-PHASE FURNACE, USING BASIC BESSEMER METAL



Sample No.	C	Mn	Si	P	S
1	.65	.32	.007	.049	.068
2	.03	.10	.007	.003	.076
3	.03	.10	.009	.027	.057
4	.17	.11	.004	.000	.057
5	.20	.12	.004	.011	.057
6	.25	.70	.179	.021	.027
7	.27	.65	.188	.023	.021

DIAGRAM 2.—PROGRESS OF REFINING OF BASIC BESSEMER METAL IN A SINGLE-PHASE ROCHLING-RODENHAUSER FURNACE AT VOLKLINGEN

Heroult furnace by the Electro Steel Works, Richard Lindenberg, Ltd., at Remscheid-Hasten, Germany. The low phosphorus and sulphur content of various kinds of carbon and alloyed steels made in the Girod electric furnace at their works in Ugine, France, is shown in Table 2. This also gives the complete analysis of the different steels.

The high temperature of the electric furnace makes it possible to use highly basic refining slags, which impart briskness and intensity to the reactions. Thus the chemical equilibrium between the molten metal and the slag favor the purification of the bath. By sufficient additions of iron ore, exceedingly soft metal is obtained with a maximum of about .075 per cent. carbon, .005 per cent. of silicon, .005 per cent. of manganese. After submitting the metal to the action of these successful oxidizing slags, they are replaced by highly calcareous slags, which rapidly aid the elimination of phosphorus and simultaneously promote the elimination of the sulphur. Desulphurization occurs during the last operation, but more particularly in the last phase, when the slags are practically free from the oxide of iron and manganese. This mild and purified metal is then treated to give it the required properties. Ferro-silicon, silico-manganese, ferro-chromium, ferro tungsten, nickel, and other suitable conditions are given the bath to obtain steel of the desired composition.

The reactions that take place and the materials that are added, together with their time, are graphically shown in Charts 1 and 2.

In Table 3 is shown the chemical analyses of 23 heats, both at the be-

TABLE 3.—CHEMICAL ANALYSIS, PHYSICAL PROPERTIES AND ELECTRICAL DATA OF SEVERAL HEATS OF MILD STEEL, MADE IN A 3½-TON VOLKLINGEN FURNACE

No. of Heat.	When Analyzed.	Percentage of					Tensile Strength, Lbs. per Sq. Inch.	Elongation, Per Ct.	Contraction, Per Ct.	Time of Heat, Hrs. and Mins.	K.W. Per Ton.	Total K.W.
		Carbon.	Silicon.	Manganese.	Phosphorus.	Sulphur.						
43.....	B	.075	.018	.527	.080	.129						
	E			.594	.030	.069	90,700	21	28	2:40	300	750
46.....	B	.086	.018	.651	.087	.097						
	E		.016	.310	.018	.077	52,900	36	69	1:50	245	613
92.....	B	.067	.020	.590	.047	.077						
	E		.019	.295	.006	.048	53,200	35	64	2:00	243	610
100.....	B	.061	.018	.426	.060	.089						
	E		.023	.295	.014	.070	53,400	35	71	2:00	243	610
101.....	B	.072	.016	.558	.053	.081						
	E		.016	.328	.018	.065	48,500	39	76	2:20	270	675
116.....	B		.024	.820	.062	.065						
	E		.018	.361	.015	.044	49,800	36	67	1:50	200	500
129.....	B		.012	.720	.054	.065						
	E		.021	.361	.018	.055	51,300	37	68	1:50	258	645
132.....	B	.082	.018	.623	.072	.097						
	E		.018	.279	.015	.065	49,650	37	68	1:55	204	510
147.....	B		.026	.622	.053	.026						
	E		.029	.425	.423	.029	56,300	33	59	2:20	266	665
161.....	B		.020	.566	.049	.020						
	E		.023	.396	.005	.023	55,450	34	63	2:40	282	705
172.....	B	.070	.024	.542	.041	.024						
	E		.029	.301	.004	.029	52,200	35	62	2:15	224	560
173.....	B	.070	.020	.512	.045	.020						
	E		.028	.271	.004	.028	54,750	33	60	2:00	197	492
176.....	B		.018	.572	.065	.018						
	E		.021	.271	.007	.021	51,900	35	64	1:45	175	438
199.....	B		.026	.727	.064	.026						
	E		.034	.253	.008	.034	49,800	34	66	2:00	282	705
211.....	B	.084	.018	.569	.049	.018						
	E		.029	.348	.011	.029	53,200	35	63	2:05	293	731
212.....	B	.092	.018	.474	.095	.018						
	E		.035	.348	.019	.035	54,100	34	63	2:05	269	672
226.....	B		.020	.600	.073	.020						
	E		.021	.284	.004	.021	49,800	35	71	1:25	212	530
227.....	B		.024	.695	.061	.089						
	E		.023	.284	.008	.061	49,650	37	70	1:55	270	675
230.....	B	.116	.018	.679	.054	.097						
	E		.122	.695	.028	.048	81,400	26	51	2:05	282	705
240.....	B	.128	.032	.590	.064	.085						
	E		.140	.618	.020	.065	56,700	33	67	1:45	235	587
241.....	B		.034	.478	.060	.077						
	E		.018	.309	.011	.053	53,200	38	70	2:25	274	685
254.....	B		.028	.534	.037	.081						
	E		.022	.307	.005	.057	52,100	37	67	1:50	250	623

NOTE.—B means beginning, and E, ending of each heat.

ginning and end of each heat. These show the average results obtained in a 3½-ton Rochling-Rodenhausen furnace at the Völklingen Works in Germany. The physical properties and time consumed in purifying each heat are also given, as well as the electrical consumption. These stills are being manufactured on a commercial scale.

About the only objection that can be raised to the electric furnace is the high cost of the electric current. Even with this, however, it is cheaper than the crucible method of producing steel. As the quality of steel is much better when made in the electric furnace, there is no good reason for the use of the crucible method, and it is bound to be supplanted in time. For the cheaper steels, such as are made in the Bessemer converter and open-hearth furnace, there can be little chance for the electric process unless our coal fields should become exhausted.

Three divisions might be made in the treatment of steel in electric furnaces. These are melting down, oxidizing the phosphorus and any excess of carbon and silicon present in the molten metal, and removing the sulphur, occluded gases, etc. The first two operations can be, and are, performed more cheaply by the older processes. The third and last, however,

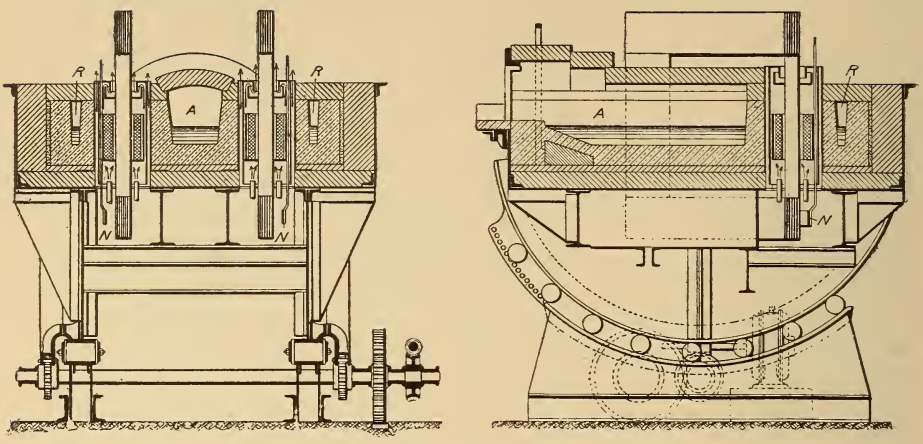


FIG. 4.—SECTIONS OF THREE-PHASE COMBINATION ELECTRIC STEEL FURNACE

is done much better in the electric furnace, and when high grade steels are required they can be given the final refining cheaper than by any of the older processes.

That nitrogen and hydrogen are very injurious elements in steel has been clearly proved, and also that they are present in larger quantities than was formerly supposed. It has also been demonstrated that these are more completely removed in the electric furnace than in any of the older processes, not excepting the crucible. That the nitrogen and hydrogen are lower in electric furnace steels than in those made in crucibles is rather surprising, but it is not surprising that they are higher in other processes.

This may be due to the formation of acetylene, or other hydrocarbons, on the surface between the metal and slag—i. e., where these come in contact with one another. As more time can be given to the "killing," which in the older processes is too often attempted in the ladle or as the metal is running into it, this doubtless aids in the removal of these occluded gases, as well as oxygen, by allowing them to raise to the slag, similar to the manner in which cream rises to the top of milk.

By removing the occluded gases the impurities do not have as injurious an effect as they otherwise would. Sulphur, especially, is not as injurious when these gases are removed so it cannot form combinations with them. If the other impurities are *nil,* the sulphur content of steel may be comparatively high before any injurious effects are noted. With the occluded gases removed, there is a conspicuous absence of blowholes, checks, surface flaws, snakes, etc., in the finished steels. It also enables a higher carbon content to be given the steel for an equal toughness.

Whether the heat be generated by passing the current through the metal itself, or between electrodes, which heat the metal by radiation, or by

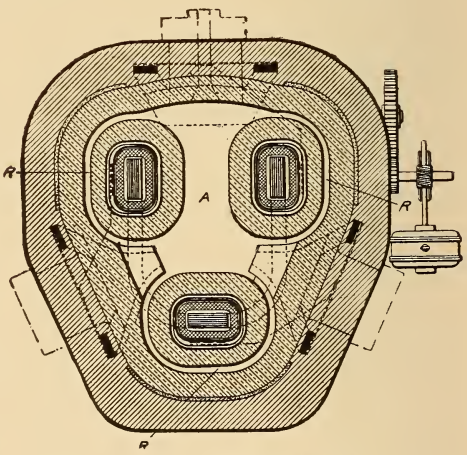


FIG. 5.—PLAN OF THREE-PHASE COMBINATION FURNACE

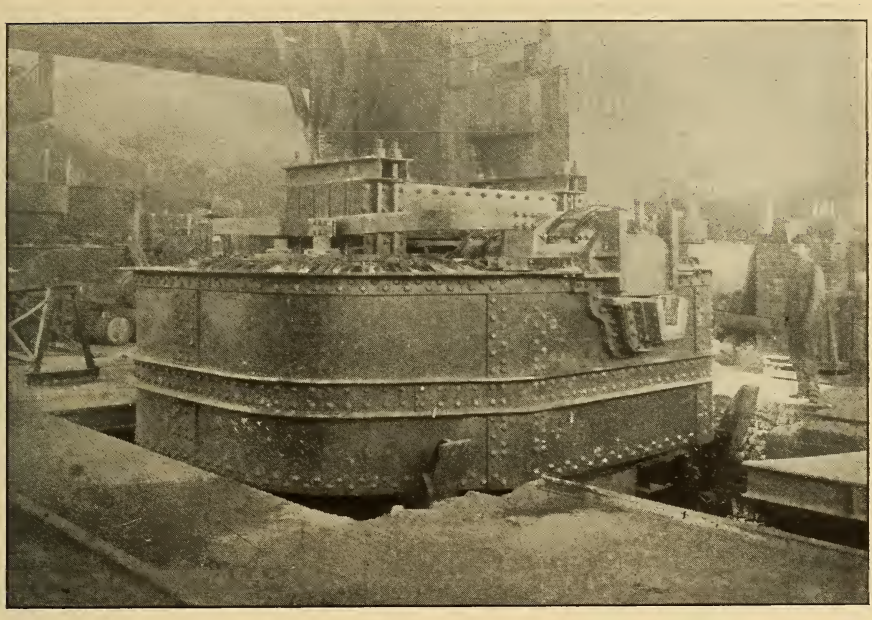


FIG. 6.—ROCHLING-RODENHAUSEN SINGLE-PHASE ELECTRIC STEEL FURNACE OF 8-TONS CAPACITY

both, it is doubtless true that short circuits occur in the metal and aid the refining operations to a considerable extent. These keep the metal in motion, even after it has been completely "killed," and assist the occluded gases to escape into the slag. To convince old steel makers that the metal in electric furnaces is completely "killed," it is necessary to shut off the electric current and stop the motion in the bath.

That it is the impurities in steel which weaken it goes without saying, and thus the steel-making process that will remove the largest proportion of these impurities will produce steel with the greatest static and dynamic strengths. The tensile strengths and resilience obtained in soft, medium and hard carbon steels made in the Girod furnace at Ugine, France, are shown in Table 4. The test bars were pulled after the steel had been thoroughly annealed, and again after it had been hardened and tempered at the temperatures given.

Another result that was obtained from a charge of very impure pig iron is shown in Table 5. With this the analysis is given before and after charging.

TABLE 4.—PHYSICAL PROPERTIES OF VARIOUS CARBON STEELS MADE IN GIROD ELECTRIC FURNACE

Kind of Steel and Heat Treatment.	Tensile Strength, Lbs. Per Sq. Inch.	Elastic Limit, Lbs. Per Sq. Inch.	Elongation in 2 Inches, Per-centage.	Reduction of Area, Per-centage.	Resilience, Pounds.
Soft Steel:					
Annealed at 1,650° F.	58,850	41,875	31	60	94.6
Hardened at 1,475° F. and tempered at 1,100° F.	76,950	64,375	22	74	105.6
Mediums Soft Steel:					
Annealed at 1,650° F.	71,425	44,750	29	60	72.6
Hardened at 1,475°F. and tempered at 1,100° F.	86,859	41,000	21	66	77.0
Medium Hard Steel:					
Annealed at 1,650° F.	92,375	57,325	21	34	26.4
Hardened at 1,475° F. and tempered at 1,100° F.	113,325	91,050	14	37	35.2
Hard Steel:					
Annealed at 1,650° F.	97,875	60,175	17.5	30	19.8
Hardened at 1,380° F. and tempered at 1,100° F.	137,125	114,850	9	30	26.4
Very Hard Steel:					
Annealed at 1,475° F.	113,325	65,925	16	30.5	19.8
Hardened at 1,380° F. and tempered at 1,100° F.	142,825	111,950	9.5	49	26.4

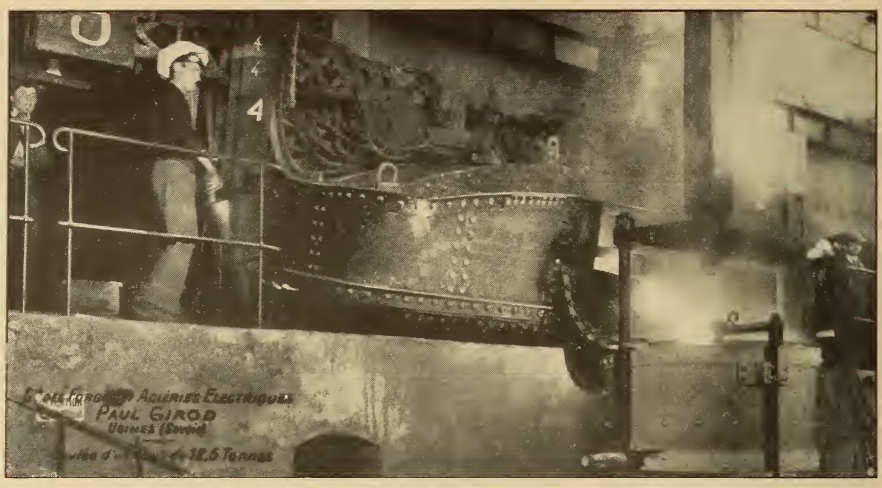


FIG. 7.—GIROD ELECTRIC STEEL FURNACE OF 12½ TONS CAPACITY, AT UGINE, FRANCE

TABLE 5.—RESULTS OBTAINED FROM A CHARGE OF VERY IMPURE PIG IRON IN AN INDUCTION FURNACE IN FIVE HOURS

Analysis of Heat

	Before Charging, Per Cent.	After Charging, Per Cent.
Carbon	4.00	0.500
Silicon	1.00	0.056
Manganese	0.00	0.760
Phosphorus	1.80	0.025
Sulphur	0.20	0.030

Mechanical Properties

Breaking stress, pounds per square inch	95,000
Elongation, per cent	20
Contraction, per cent	36

At the John Cockerill steel plant in Seraing, Belgium, the Girod electric furnace is used for making the highest grade of steel for car axles and locomotives tires and tanks. The Belgium National Railroad is a large user of these, and they demand great strength and durability. Some recent drop tests that were carried out at these works are given in Table 6. The first two steels tested were the Belgium Railway's standard locomotive tire and tank steel and the last two are of Queensland type of axles. In the four tests the distance between supports was 42 inches and the weight of the drop 2,204 pounds. The Queensland axles were 4⅛ inches in diameter and their initial curve 1/5 of an inch.

Since the advent of the electric furnace steels, the Prussian Government has endeavored to encourage the industry by drawing up a set of specifications for steel rails and purchasing those that met their requirements. In these the designated strength for track rails is 99,000 pounds per square inch and for switch or point rails 160,000 pounds. A minimum bend of 3 3/16 inches, on a rail 39½ inches between supports, and struck with a falling weight that delivered 10,800 foot pounds, was also specified, and the elongation in 8 inches must be 10 per cent. or more. A guarantee of ten years must be given for the life of the track rails, and seven years for switch rails.

The Thomas rail has been used almost universally in Prussia. This is a basic Bessemer rail and compares with American Bessemer rails. That it is much inferior to the rails rolled from steel made in the electric furnace is shown by the average analyses and strengths of both that are given in Table 7. They are fairly representative of the rails that are commercially produced in Prussia. Some very complete tests that were made on three specimens of electric steel rails for the Prussian State railway are given in Table 8.

Some electric steel rails were made for the Metropolitan Railway Co., London, that contained carbon 0.78 per cent.; silicon, 0.196 per cent.; manganese, 0.285 per cent.; sulphur,

TABLE 6.—DROP TEST MADE ON ELECTRIC FURNACE STEEL USED FOR LOCOMOTIVE TIRES AND CAR AXLES

Number of Drops.	Distortion in Inches. Height of Drop. 33 Feet.	24 Feet.	25 Feet. Turned Up.	Turned Over.	Turned Up.	Turned Over.
1	2.00	1.64	5.96	...	5.44	...
2	3.76	3.04	...	0.2	...	0.2
3	5.28	4.20	5.52	...	5.28	...
4	6.68	5.36	...	0.2	...	0.2
5	8.04	5.48	5.32	...	5.28	...
6	9.28	5.72	...	0.2	...	0.4
7	9.72	8.28	5.28	...	5.40	...
8	11.32	9.16	...	0.2	...	0.2
9	12.84	10.04	5.64	...	5.32	...
10	13.92	11.00	...	0.4	...	0.4
11	15.36	11.80	5.44	...	7.68*	...
12	15.88	12.60	9.32	...	...	1.2†
13	17.00	...	...	3.80	6.80†	...
14	17.84	...	...	1.72	...	1.2†
15	18.76	...	4.40	...	...	...
16	19.48	...	...	...	...	...
17	20.44	...	...	...	...	...
18	21.24	...	...	...	...	...
19	22.04	...	...	...	...	...
20	22.84	...	...	...	...	...

* Drop, 36 feet. † Drop, 26 feet.

0.035 per cent.; and phosphorus, 0.022 per cent. By the Brinell hardness test, with a 19 mm. ball and 50 tons pressure, these rails showed an impression 3.7 mm. in diameter. With a 2,240-pound weight dropping 25 feet, a deflection of 3.56 inches was shown on the first drop. The second drop of 21 feet did not break it, and a third blow was given it with a 37-foot drop before the rail broke. Some 80-pound electric steel rails were made in the United States with a carbon content of 0.80 per cent. One of these required four drops of a 2,000-pound weight before it broke when placed on supports 4 feet apart. The first drop was from the height of 20 feet and showed a deflection of 2.05 inches; the second drop was 10 feet, and showed a total deflection of 3.05 inches; the third drop was of 10 feet, and showed a total deflection of 4.2 inches; and the fourth drop of 10 feet broke the rail.

The use of the electric furnace for making steel rails will probably never become very general, owing to the cost of operation. For some special places it might be advisable to use such steels, owing to their greater strengths, but rails can doubtless be produced much cheaper by other methods. For instance, for steels that must withstand considerable wear, like those located on sharp curves, it has been demonstrated that titanium added to Bessemer steel will give the desired results. These can be obtained at a cost of production that is much cheaper

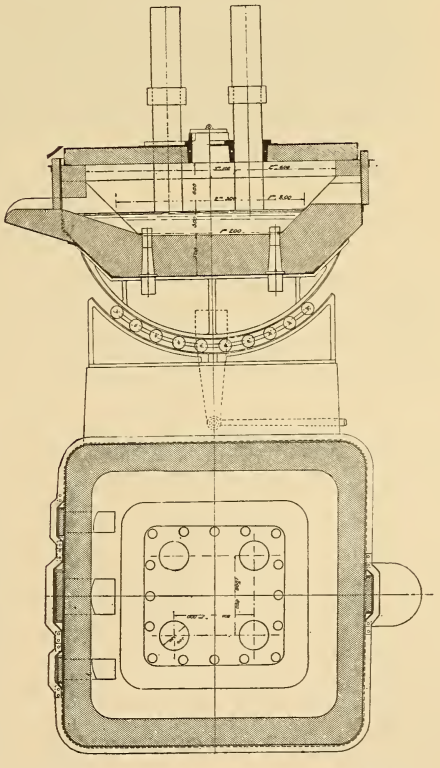


FIG. 8.—DETAILS OF 12½-TON GIROD ELECTRIC FURNACE

TABLE 7.—AVERAGE OF SIX CHARGES FOR ELECTRIC FURNACE RAILS, AND SIXTEEN CHARGES FOR THOMAS RAILS

Kind of Steel.	C.	P.	S.	Mn.	Si.	Tensile Strength, Lbs. Per Sq. In.	Elongation in 8 Ins, Per-centage.	Reduction
Electric	0.54	0.056	0.042	0.984	0.21	119,000	15.4	24.1
Thomas	0.36	0.073	.....	1.127	....	97,000	17.6	26.2

than steels made in the electric furnace. Other methods are also being applied to the manufacture of steel rails that are greatly benefiting them, and thus overcoming any necessity for an expensive method of production. However that may be, the results obtained from the tests carried on for the Prussian and Belgium Governments have resulted in a great deal of valuable data being compiled. These data have shown the possibilities of the method, and just what results may be expected from steels made in electric furnaces.

As an auxiliary to the open-hearth furnace, the electric furnace has shown itself to be a great success. In the open-hearth furnace, gas is constantly supplied and sufficient oxygen to generate the combustion goes with it. If this oxygen is regulated correctly, the flame is reducing; that is, only enough oxygen is present to unite with the carbon and generate perfect combustion. This, however, is very difficult to regulate in actual practice. Many times, when a furnace is thought to have a reducing atmosphere, it is very oxidizing and hence the metal absorbs more or less of the gases present. By using the electric furnace as an auxiliary to the open-hearth, many bad features are overcome. The steel can then be given its rougher purifying in the open-hearth furnaces, and transferred to the electric furnace to be given its finishing

TABLE 8.—TESTS OF ELECTRIC STEEL RAILS MADE FOR THE PRUSSIAN STATE RAILWAYS

Number of Blows.	Height of Drop, Feet.	Inch Pounds.	Deflection in Inches.	Equivalent Height in Ft. with Tup Weighing 2,240 Lbs.	Equivalent Height in Ft. with Tup Weighing 2,000 Lbs.	Depth, Inches (Brinell Test).	Hardness, Number (Brinell Test).	Tensile Strength, Lbs. Per Square Inch.	Elongation, Per Cent.	Contraction, Per Cent.
Specimen I.										
1. Head up.....	24.93	50,650	2.362	19.59	21.94	.125	250	123,341	12	21
2. Head down...	16.40	33,350	Straight	12.88	14.43					
3. Head up.....	26.56	54,000	2.913	20.88	23.38					
4. Head down...	18.04	36,650	Straight	14.17	15.87					
5. Head up.....	27.89	56,300	3.543	21.91	24.54					
6. Head down...	27.89	56,300	Broke	21.91	24.54					
Specimen II.										
1. Head up.....	27.89	56,300	2.598	21.91	24.54	.125	250	126,172	12	17
2. Head down...	16.40	33,350	Straight	12.88	14.43					
3. Head up.....	27.89	51,300	3.150	21.91	24.54					
4. Head down...	20.01	40,650	Broke	15.72	17.61					
Specimen III.										
1. Head up.....	6.15	12,500	0.630	4.83	5.41	.129	243	122,765	14	20
2. Head up.....	6.15	12,500	1.181	4.83	5.41					
3. Head up.....	6.15	12,500	1.614	4.83	5.41					
4. Head up.....	6.15	12,500	1.929	4.83	5.41					
5. Head up.....	6.15	12,500	2.283	4.83	5.41					
6. Head up.....	6.15	12,500	2.638	4.83	5.41					
7. Head up.....	6.15	12,500	2.992	4.83	5.41					
8. Head up.....	6.15	12,500	3.307	4.83	5.41					
9. Head up.....	6.15	12,500	3.622	4.83	5.41					
10. Head up.....	6.15	12,500	3.937	4.83	5.41					
11. Head up.....	6.15	12,500	4.291	4.83	5.41					
12. Head up.....	6.15	12,500	4.606	4.83	5.41					
13. Head up.....	6.15	12,500	4.921	4.83	5.41					
14. Head up.....	6.15	12,500	5.236	4.83	5.41					
15. Head up.....	16.40	33,350	Broke	12.88	14.43					

Analysis: Carbon, 0.75; silicon, 0.10; manganese, 0.67; phosphorus, 0.023; sulphur, 0.044.

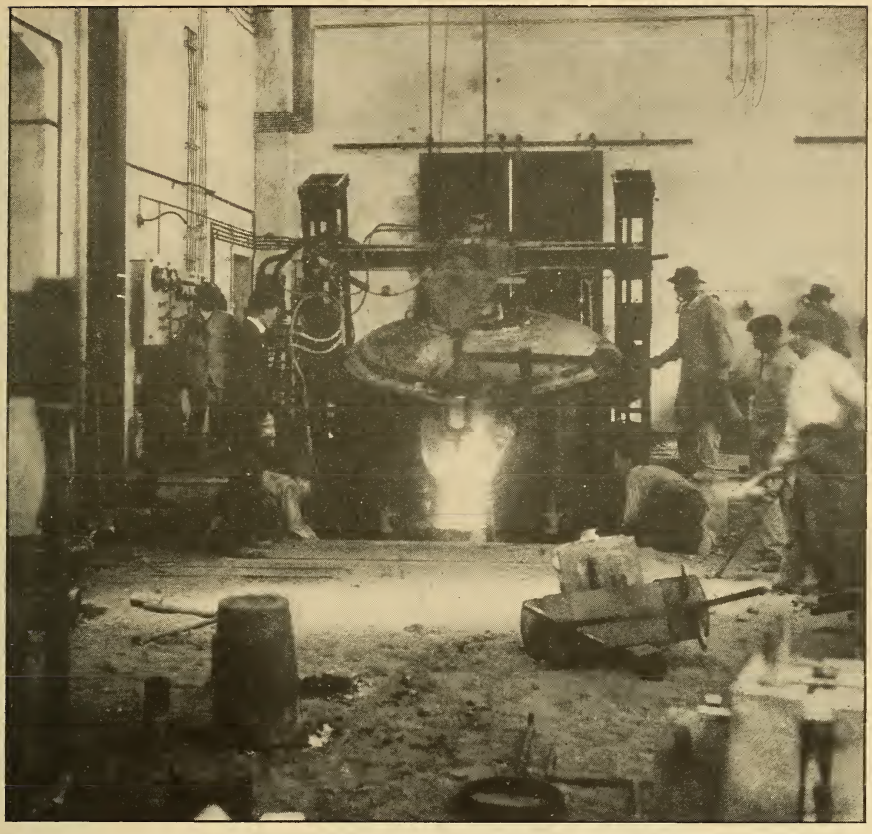


FIG. 9.—GIROD ELECTRIC STEEL FURNACE, 2 TONS CAPACITY, AT AARNE, SWITZERLAND. PRODUCING STEEL CASTINGS

purifying. Thus the electric furnace, instead of causing the abandonment of open-hearth furnaces, is really causing new ones to be built in continental Europe, which is ahead of other parts of the world on this proposition.

The improvements that have been made in the electric furnaces have made them much less difficult to handle, and the dangers to which the men were subjected that tended the furnaces have nearly been obliterated. The charging and slagging materials can be placed in the furnace with a small amount of labor. The distribution of the current has been made much more regular, so that the heat is regularly produced and evenly distributed throughout the entire mass of metal. The pinch effect which was inherent in the induction furnace but a short time ago has been entirely overcome. The losses from radiation of heat have been greatly reduced. The form and general construction of the electrodes have also been improved to an extent which makes their cost about one-half of what it formerly was. The results that have been obtained, therefore, place the electric furnace on a practical commercial basis, and the steels that are manufactured in it will be much more common in the future than they are at present.

Owing to the electric furnace producing a sound non-oxidized metal that is practically free from occluded gases, a much better carbonizing steel can be made in it than with any of the other methods. This is partially due to the fact that excessive additions of manganese and silicon are not necessary to thoroughly purify the metal. The silicon retards the penetration of

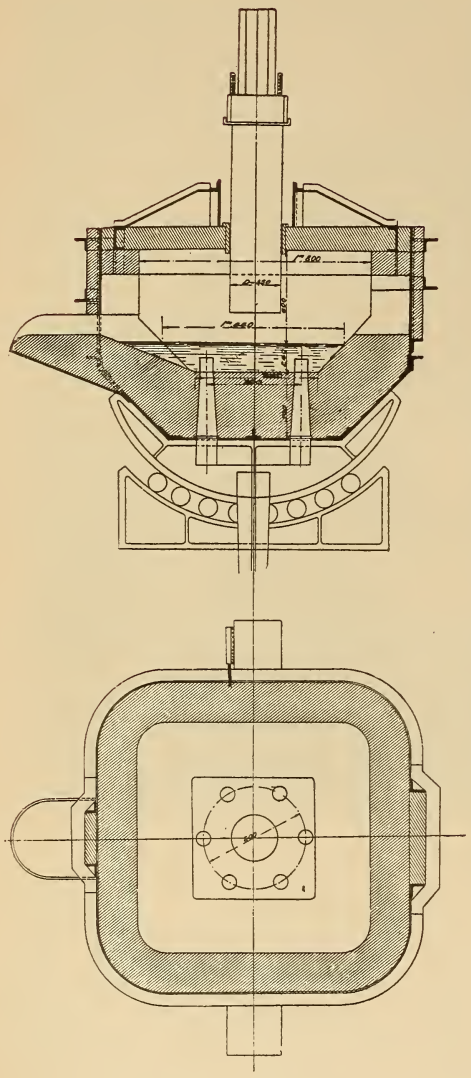


FIG. 10.—DETAILS OF 2-TON GIROD ELECTRIC STEEL FURNACE

carbon in the metal and hence should be as low as it is practical to make in steels that are to be carbonized; 5 per cent. of silicon will reduce the carbon penetration to zero. The center or core of carbonized electric furnace steels is tougher, with a high percentage of carbon in the outer shell, than are steels that are manufactured by any other process. One heat of steel that was tested by giving a Brinell ball to 10 mm. in diameter a pressure of 3,000 kilograms showed no crack on the edges. The carbonizing materials and processes that are in common use for other steels give the same results on electric steels. One steel that was packed in 40 per cent. of barium carbonate and 60 per cent. charcoal, and heated for an hour and a half at 1,650 degrees F., showed a carbon penetration of 0.039 inches.

Steels containing 4 or 5 per cent. of silicon, or 2 per cent. of aluminum, can be successfully made in the electric furnace, although it is impossible to make them by any of the other older processes. Thus it is possible to make chemical compositions in the electric furnace that are impossible to make with any other furnace. Silico-manganese steels are also commercially made in varying degrees of hardness. These are very useful for gearing, shafts, springs, etc. When annealed at 1,650 degrees F. they give an elastic limit of 91,000 to 93,000 pounds per square inch, tensile strength of from 128,000 to 130,000 pounds per square inch, an elongation in 8 inches from 15 to 18 per cent., a reduction of area of from 25 to 30 per cent., and a resilience of from 24 to 31 pounds. When hardened at 1,475 degrees F. and tempered at 850 degrees, the elastic limit is raised to from 150,000 to 182,000 pounds, with a tensile strength from 168,000 to 213,000 pounds, an elongation in 8 inches of from 6.5 per cent. to 8 per cent. and a reduction of area of 32 per cent.; the resilience being between 13 and 26 pounds.

All degrees of hardness can be obtained with nickel steels in which the nickel percentage varies from 2 to 32 per cent. Much better grades of nickel-chrome steel can also be made than are manufactured in any other kind of furnace, and many special brands of steel that show extraordinary strength are being manufactured in electric furnaces.

ELIMINATING THE DANGERS OF THE DEEP

MODERN STEAMSHIP CONSTRUCTION AND OCEAN TRANSPORTATION

By Theodore C. Deitrich

TAKE a look at the White Star Line's magnificent *Olympic* as she steams majestically into New York harbour and you will be filled with wonder, with awe, that a ship of similar construction could sink to her grave within a few brief minutes after she had received her death-wound. It seems past comprehension.

When the *Titanic* sailed on her first and only voyage, she was considered as near being a perfect, unsinkable ship as man could make her. But an unseen hand dealt her a blow that ended her career forever. The seeming impossible had happened. Equipped with every safety appliance that modern science could suggest, she sank like a rock when stabbed to the vitals. The world was filled with horror and yet—

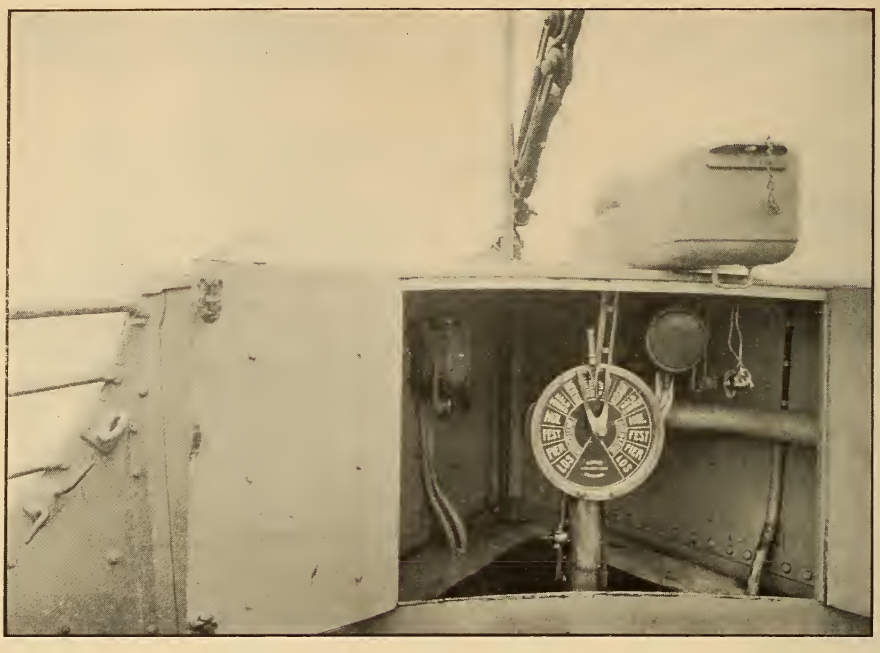
Traveling by sea to-day is safer than traveling by land, as the statistics of every country will show. I know a sea captain who shudders with terror every time he steps ashore, and is nervous and unstrung until he gets back to the safety of his cabin. I know a railroad engineer, a man who pilots a limited express, who practically falls, exhausted from the nervous strain of his "run," as he leaves the cab of his engine.

Perhaps more money is spent each year in an effort to secure absolute safety at sea than for any other single cause. The officers and engineers of every great steamship company are accessible at all times to the inventor who has a safety device. He is given a hearing, and if his idea is at all feasible the company will make a practical test. And what a horde of inventors has swooped down upon them within the past few months! Most of their propositions were impracticable. A few—a very few—may some day add their mite in the great endeavor to save life.

Among these is the Sperry gyro-compass. More than 2,000 years before the Christian Era, the Chinese invented the magnetic compass, and ever since then we have been using it with the utmost confidence. Now, it seems, the magnetic compass is all wrong. Instead of being "true as the needle to the pole," as we have been ever taught, the fidelity of the needle is nothing more than a poor, weak tendency to point somewhere near a constantly shifting spot many hundreds of miles from the real pole. The gyro-compass, based on the principle of gyroscopic phenomena, has, its inventor claims, not a "tendency" to point true north, but a "determination" to do so. Thus, when one steamship receives a distress call from another, it can, with the gyroscopic compass, go direct to her, and not be deceived by magnetic influences causing compass variations.*

To construct the unsinkable ship is the great aim of the companies. Bulkheads and water-tight compartments have gone a long way toward this end, but the latest thing to be experimented with is a ship within a ship. Professor Kretschmer, of the Technical High School at Charlottenburg, has completed plans for such a ship,

* For a fully illustrated description of the Gyro-Compass see CASSIER'S MAGAZINE for October, 1911.



TELEGRAPH FROM BOW OF SHIP TO MAN AT THE WHEEL

WHEEL-HOUSE ON S.S. KRONPRINZESSIN CECILIE. ALL THE MECHANISM OF THE SHIP IS CONTROLLED FROM THIS CENTRE

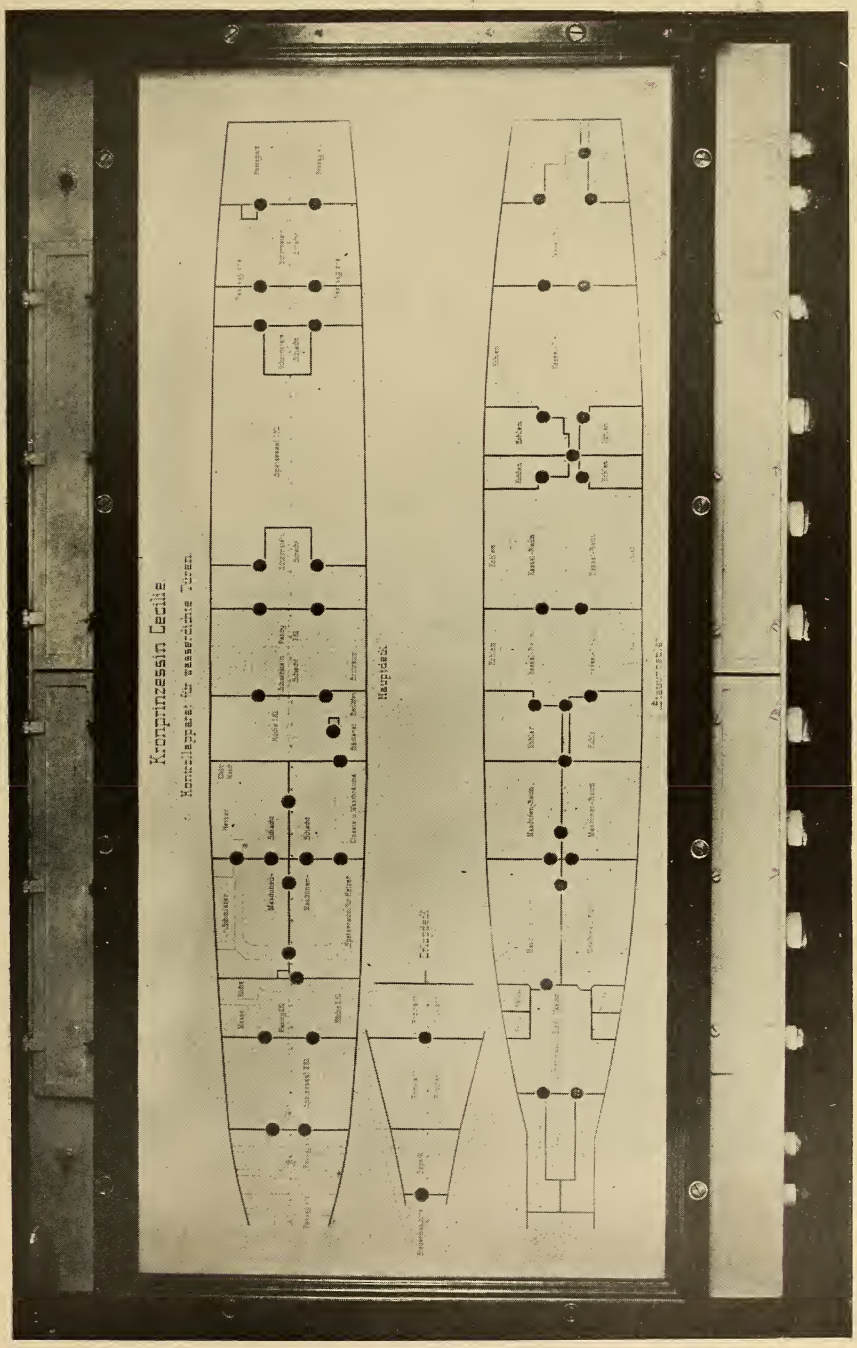
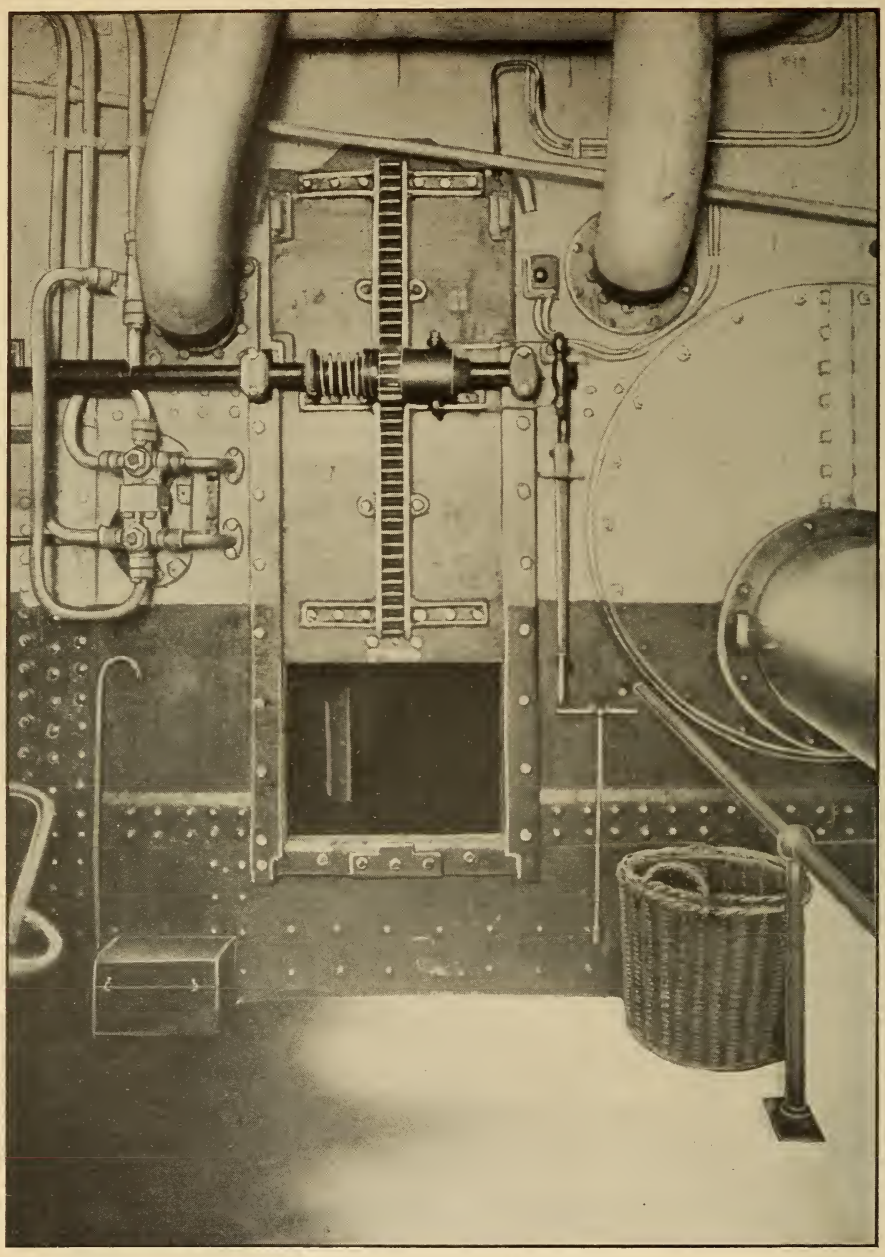


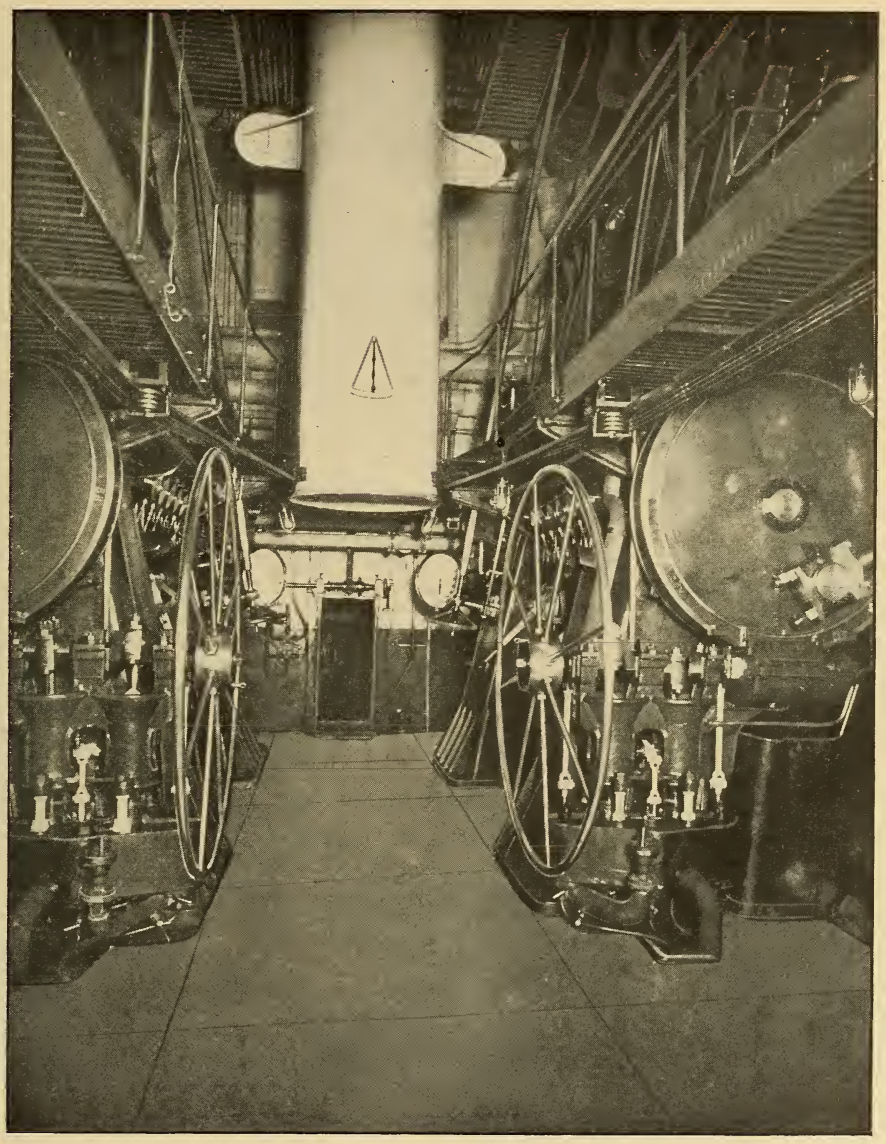
CHART SHOWING LOCATION OF WATER-TIGHT BULKHEAD DIVISIONS AND DOORS

Each spot indicates a door, and when doors are closed a red light glows in the glass frame at door location



MECHANISM FOR CLOSING WATER-TIGHT DOOR

which have been presented to the North German Lloyd. These plans are now being carefully examined, and if they are found to be practicable, as it is believed, will be applied to the new North German Lloyd steamship *Columbus*. Professor Kretschmer's plans call for a ship 714 feet long, 98 feet beam, 26 feet draft, 40,000 horse-power engines, and capable of making a speed of 28 knots. Its essential feature is that it shall contain within an outer hull a second framework completely encased and water-tight—practically a ship within a ship. The lower decks

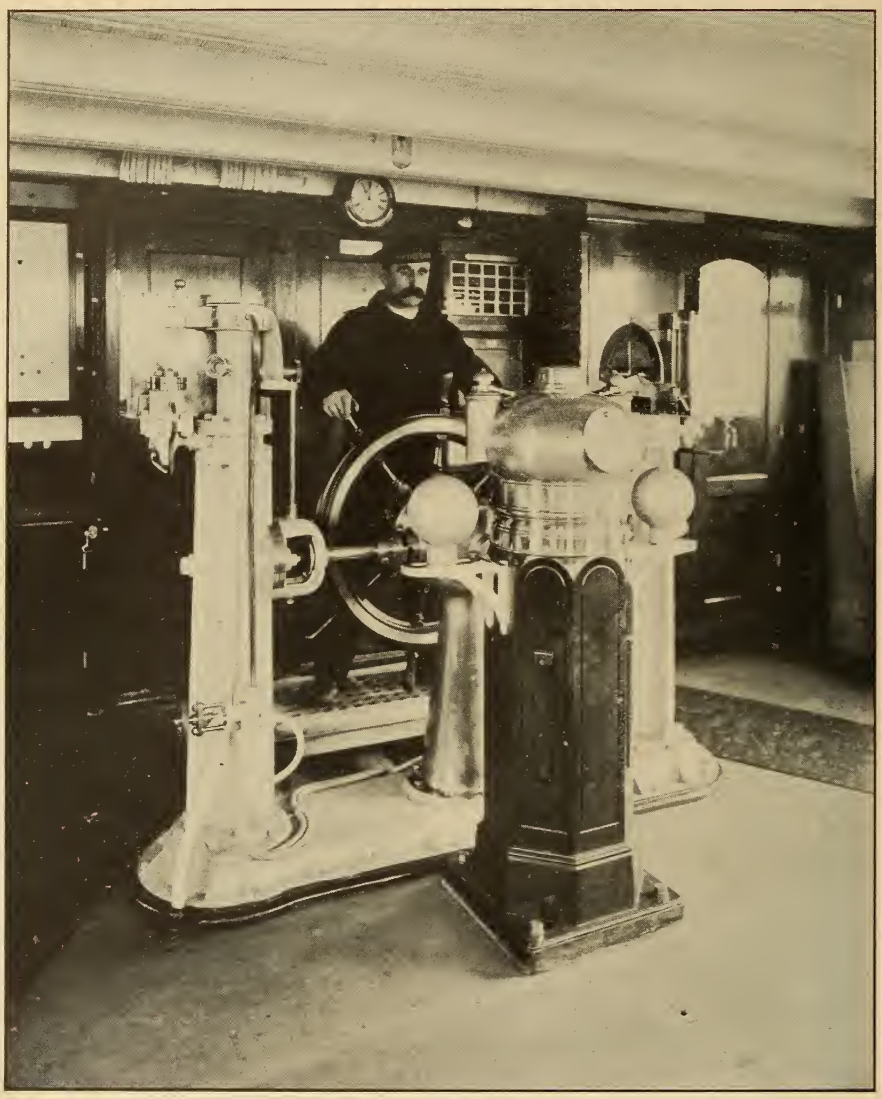


BULKHEAD DOOR AND AUTOMATIC CLOSING GEAR IN ENGINE ROOM

of the interior ship will contain the boilers, machinery and coal bunkers.

To make its construction feasible and to secure greater stability, the hull will be tetrahedral in shape, sharply pointed at the bows, and will widen to a point well aft near the stern, where the ship will measure its greatest breadth. It is claimed that the ship will reduce water resistance, increase the steaming capacity and speed and reduce coal consumption.

The German Emperor is much interested in this experiment, as one of the highest ambitions of the Kaiser is to find the unsinkable ship and to make sea travel absolutely safe. It is a well-known fact that the German shipping laws are more stringent than those of any other nation, but still the Kaiser is not satisfied. A meeting was held in Berlin on May 6 last to



THE QUARTERMASTER AT THE WHEEL. ALL STEERING APPARATUS IS IN TRIPLICATE

discuss protective measures for marine transportation. It was attended by imperial officers, the Prussian Ministry and representatives of the German steamship companies. The Kaiser especially and repeatedly emphasized that in the measures to be given the most weight must be laid on increasing the floating power of steamships; secondarily, the protection of travelers through the perfection of the wireless telegraph service; provisions for the rescue of every passenger and member of the crew and the extension of the boat register.

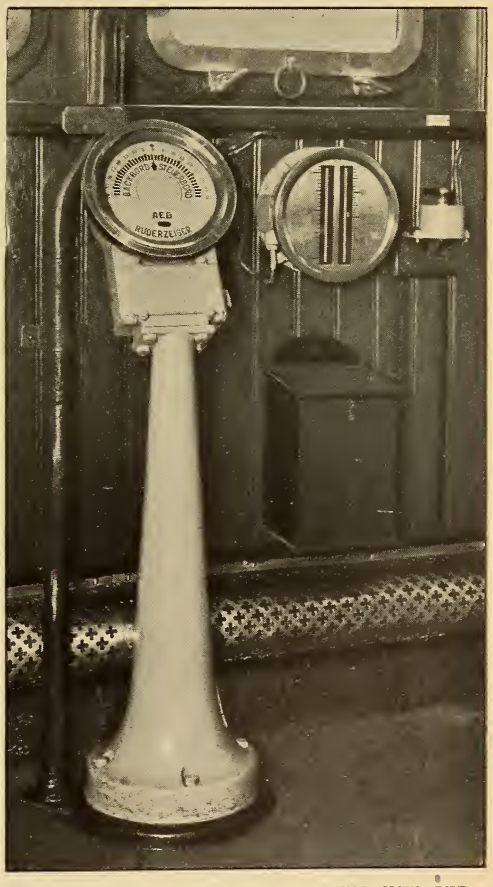
The Kaiser brought up the question of searchlights upon transatlantic liners and asked whether their use would not diminish the dangers from ice during the night. Almost unanimously the meeting answered in the negative. Old, experienced captains present declared that the glare of the searchlight on the water blinds the watchers on the ship for several minutes after the ray of light has been

ELECTRICAL DEVICE FOR RELEASING LIFE RINGS AND BUOYS ON CRY OF "MAN OVERBOARD"

Unless all rings are released, a red light glows in the white case above

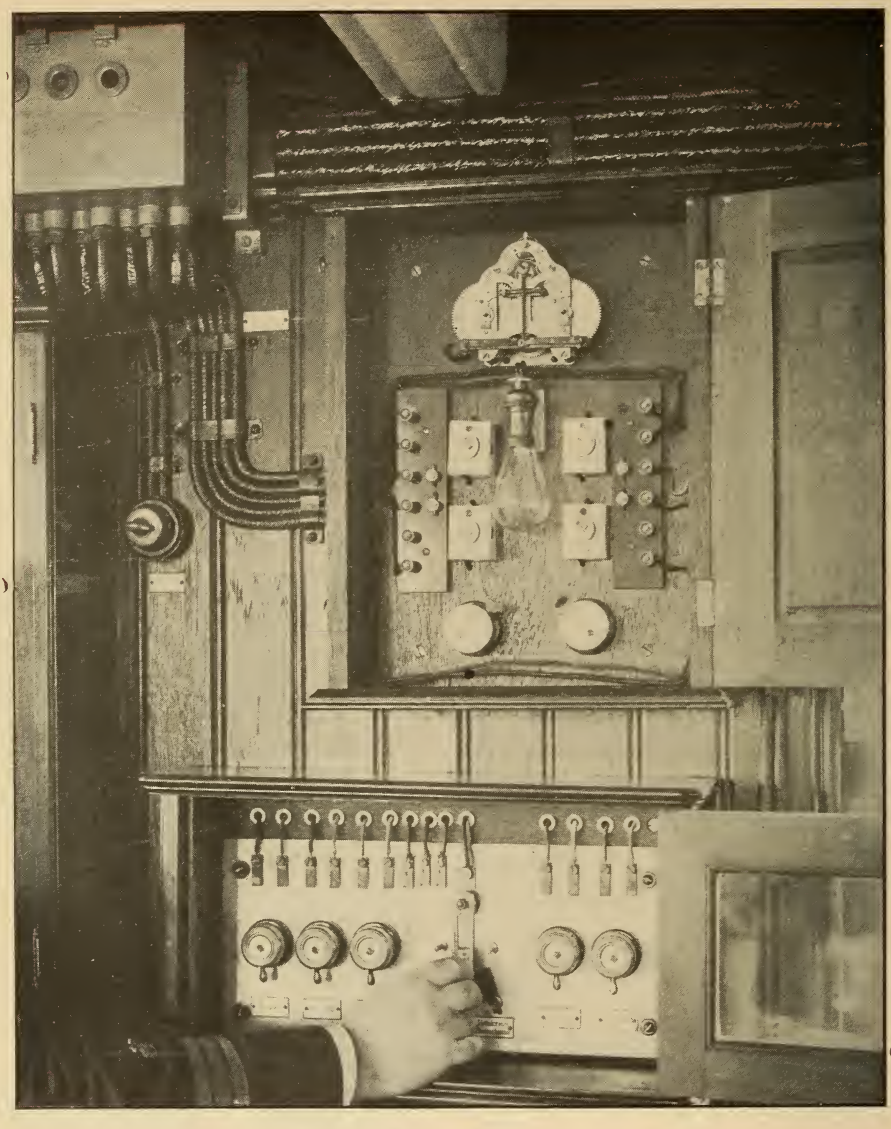
shifted in another direction. It is also useless in fogs, as the rays will not penetrate their density. For many years not one transatlantic liner carried a searchlight. Then, when the North German Lloyd completed their splendid steamer *George Washington,* she possessed everything else tending to safety, so she was given a searchlight. It is still somewhere on the *George Washington*—the captain probably could find it—but it has never been used. Recently a searchlight was also placed upon the *Kaiserin Auguste Victoria,* and, so far as records show, they are the only passenger liners carrying them.

Wireless telegraph and submarine signals have done more to make sea travel safe than any other agencies. And yet, who ever hears of submarine signals, or, hearing, realizes what they are? The wireless telegraph is the dramatic, the theatric agency of safety. The submarine signal is the man behind the gun. An officer of the steamship *Baltic* told the writer that the submarine signals played as important a part in the rescue of the passengers and crew of the *Republic* as did the wireless telegraph and Jack Binns. It was the monotonous ringing of the Nantucket lightship's bell, fathoms below her keel, that told the men on the wounded and drifting *Republic* where they were; and from



ELECTRIC RUDDER TELEGRAPH, SHOWING HOW THE RUDDER RESPONDS TO THE STEERING GEAR

A revolution indicator is shown on right



SIGNALING MECHANISM ON SHIPBOARD

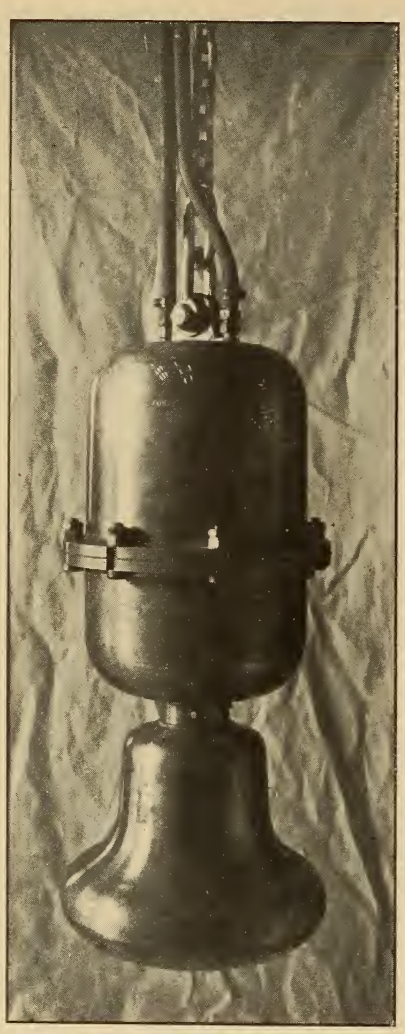
The clockwork is for sounding the fog horn at regular intervals. The small discs in the upper right-hand corner indicate whether the side and mast-head lights are burning or not. The switchboard enables stewards, firemen or engineers to be summoned in case of accident.

this submarine signal it was possible to estimate that they were from ten to fifteen miles from the lightship. Then the wireless stretched its electric finger through fog and mist and gave that despairing cry which brought succor to the 825 persons aboard the *Republic*. The wireless and Jack Binns got the credit, but without the submarine the precious cargo of the *Republic* might have gone to the bottom of the ocean.

Do you remember going in swimming when a boy, and cracking two stones together under the water and how the sound would carry? That's the fundamental principle of the submarine signal of to-day. The system depends on the well-established fact that sound travels farther and

WHEEL ON BRIDGE FOR CLOSING ALL WATER-TIGHT DOORS. A BELL IS RUNG SEVEN SECONDS BEFORE DOORS BEGIN TO CLOSE

with more accuracy through water than through air. The uniform density of water makes it a much better conductor. Traveling through air, sound is diverted by fog-banks, by clouds, by the strength of winds and by its varying density. Traveling through water, it has none of these things to contend with. An invention of two Americans, Mundy and Prof. Elisha Gray, the apparatus consists in its main part of a submarine bell attached to the hulls of lightships, buoys, etc., the corresponding receiving apparatus being installed within the hull of ships, at the bow, whence the bell signals are transmitted by telephone to the chart house. Each lightship or buoy has a private code which it tolls off hour after hour, day after day, giving its exact location by a series of ever-repeated bell-taps. These bell-taps are distinctly audible at a distance of four or five miles and



A SUBMARINE BELL FOR SIGNALING POSITION OF SHIP DURING FOGGY WEATHER

have sometimes been picked up fifteen miles distant. In the hull of the ship are two receivers, one on either side, and inside of the plating and between the keel and water-line. By listening to one after the other of the receivers it is possible to determine with remarkable accuracy, as has been proved by experience, whether the lightship or buoy is on the port or starboard side.

To the submarine signals and the wireless is due the credit of one of the most remarkable performances ever known at sea—the landing of passengers, mail and baggage from a steamship without the officers or crew seeing the port. It was on an eastward trip of the North German Lloyd's *Kaiser Wilhelm II* that Captain Cueppers ran into a great bank of fog just before he was to enter Plymouth. He was anxious to make the port, but the density of the fog apparently precluded all thought of so doing. Fifteen miles out the *Kaiser Wilhelm II* picked up the submarine buoy-signal. But let Captain Cueppers tell the story:

"There was a heay fog on approaching the channel. Neither Scilly nor Wolf Rock was sighted. As we could not hear the fog signal, on nearing the Lizard, I made inquiry by wireless and received a reply from the Marconi station on the Lizard that our steam whistle had been heard two or three points to the south.

"In order to be absolutely certain, I notified the station that I would blow the whistle three times and requested to be informed whether or not the signal was heard. The station asked me to give the signals agreed on after waiting two minutes.

"When this was done the station advised that the signals had been plainly heard abeam. I, therefore, held toward Eddystone and notified the Lloyd agents in Plymouth by wireless to have the tenders wait for us outside the port.

"At 4.40 o'clock in the afternoon we heard the signals of the tenders for the first time and anchored. The tenders came along ten minutes later, and we landed passengers, mail and baggage, and continued on our trip to Cherbourg at 5.35 o'clock without even having seen Plymouth."

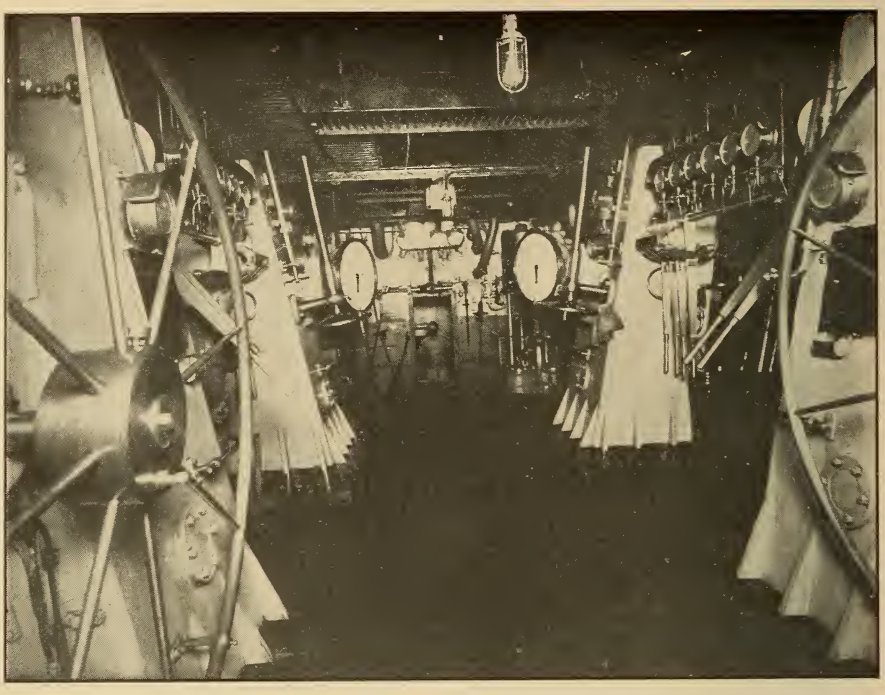
Captain Polack, of the North German Lloyd's *Kaiser Wilhelm der Grosse,* during a trip from New York to Plymouth, Cherbourg and Bremen, used the wireless to good advantage. The *Kaiser Wilhelm der Grosse* lost her rudder and rudder-post off the Newfoundland Banks. Capt. Polack immediately sent the news to the Lloyd agents in New York

LISTENING FOR THE SUBMARINE BELL

A telephone to each ear indicates the side on which another ship is approaching. The telegraph on the right transmits orders to the engine room, besides recording exact time and nature of order.

that he intended steering his ship into the ports for which she was bound by her propellers. Although encountering rough weather, he was successful and arrived only twenty-four hours behind his schedule. The wireless was used daily by him to tell of his progress. The Kaiser was so pleased by this excellent display of seamanship that he awarded to Capt. Polack the Order of the Crown of the Third Class in recognition of his work.

Everything from the bridge or the wheelhouse of a modern steamship radiates. It is the brain, the nerve-center of the entire ship. The touch of a finger to an electric button or the turn of a wheel will accomplish in a fraction of a second what formerly took hours, or was wholly impossible. And for every wonderful piece of mechanism there is a counterpart in



VIEW OF ENGINE ROOM, WITH DOOR CLOSING THE ROOM COMPLETELY

some other part of the ship, so that if one is disabled the other can be used. Sometimes, too, in the more important instances, the apparatus is in triplicate.

The dynamos which furnish light for the ship and power for the wireless are in a separate water-tight compartment, as completely apart from the engines and boilers as if they were on another ship. Even though both engines and dynamos should be disabled, an auxiliary engine has been established with sufficient power to light the ship and supply the wireless with current. Put these out of commission, too, and there is still left in the Marconi house two complete sets of storage batteries, each capable of keeping the wireless supplied continuously for 24 hours.

Telephones connect every part of the ship with that great brain, the bridge, and every order that is given from the nerve-center is automatically recorded. There is no such thing as denying if the wrong instructions were issued, for every order from the bridge is repeated back on a "ticker" appliance and printed on tape, with the time, even to the second, that the order was given, and who gave it. No one can open this "ticker" and see its contents except the inspectors at the home port.

The wheel house is a mass of dials, thermometers, barometers, telegraph and telephone instruments, levers, thermostats and switches. By turning a wheel on the bridge, all the bulkhead doors below the water-line may be closed within twenty seconds. These great half-ton doors, in closing, would crush a six-foot log of oak as neatly as you would break a match. They make every compartment that they enclose as independent of the others as if they had no connection whatever with them.

The greatest dread of the mariner is not fog, nor ice, nor tempest, but fire; and every precaution is taken to guard against it. The bulkheads have accomplished wonders. Let a fire start in a certain part of the ship and the great doors of that particular com-

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FIRE-FIGHTING APPARATUS, WITH SMOKE HELMET AND FRESH-AIR BELLOWS

partment are closed, shutting it off from other parts of the ship. Live steam and water are forced in, but these proving inadequate, the compartment is sealed up by the great doors, and with all air shut off, the fire must soon burn itself out.

Every precaution is taken to prevent fire in the upper part of the ship. Thermostats are everywhere. The instant the temperature in any part of the ship arises beyond a certain point, a bell rings in the wheelhouse, and, in the square on the indicator to correspond with the location of the thermostat, a red light flashes. The officers on duty know instantly the location of the fire. The crew, equipped with every known fire-fighting appliance, has a fire under control before it is well started.

In case of accident at sea everything depends upon the heroism of the crew. A grizzled engineer wiped

BOAT DRILL WITH STOKERS AT THE OARS

away tears of pride as he told me that "ten of my boys went down with the *Titanic,* keeping the engines going to the last, that others might live, even though they died." The members of the crew — engineers, stokers, stewards and waiters—all play their part. I saw a lifeboat manned with waiters, lowered away from a Royal Mail Steam Packet Company steamship lying off Antilla, Cuba. They gave as pretty an exhibition of expert rowing as one would care to see. On the other side of the ship was lowered another boat, manned by stokers. Both boats were rowed fully a mile from the ship, and then raced back as though the very lives of the occupants depended upon the result. This practice at sea is held on every trip of the Royal Mail steamships.

A life-saving manœuvre in which the passengers participated was recently successfully undertaken by the

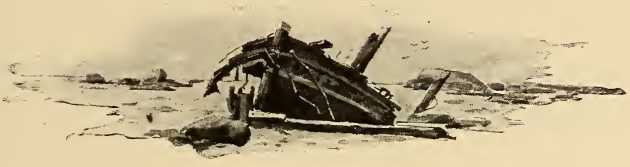
WAITERS MANNING A LIFE-BOAT DRILL

Austro-American Line. The steamship *Martha Washington* stopped off Fayal, Azores, filled the lifeboats with passengers and crew, and thirteen minutes after the alarm was sounded the outer as well as the inner rows of lifeboats were in the water.

We have heard much recently about sacrificing safety for speed and luxury. This is all a fallacy. Steamship companies do not take chances on losing a ship worth millions in money, to say nothing of human lives.

Charles von Helmolt, general manager for Oelrichs & Co., general agents of the North German Lloyd, who has done as much as any living man toward securing safety at sea, told me:

"Speed is always sacrificed to safety. The steamship companies of the world would not countenance construction which would enhance speed at the expense of safety. The great ocean steamships are as safe as human endeavour can make them. But the devices have not been added in a day. They are the growth of years of experiment and experience."



THE COMMERCIAL VALUE OF THE ILLUMINATING GAS ENGINE

By Edwin D. Dreyfus

THE internal combustion engine truly owes its existence to the illuminating gas industry. While in reality it was first conceived by Huyghens in 1680 to use gun powder in an "explosion" motor, successful application of coal gas followed a short time afterward. During the first half of the nineteenth century the gas engine improved only slowly, but, nevertheless, quite satisfactorily, considering the surrounding conditions. Between 1860 and 1870, about the time the work of Lenoir and Otto and Langen appeared, the gas engine actually began to assume commercial importance. All engines built prior to 1880 were designed for coal gas. At approximately this period, Dawson brought out a gas producer intended primarily for power purposes. After the lapse of a few years, oil engines were introduced, and in about 1895 the signal development of blast furnace and natural gas work was started. The two later fields have, owing to the cheapness and suitability of the gas, created the greater demand for the gas engine.

While illuminating gas power has not depreciated in economic value in small sizes, its notice has been largely subdued by the prominence lately given the construction of large gas power plants.

USE OF LARGE ILLUMINATING GAS ENGINES

There are, however, special applications where the large powered engines may be advantageously connected to the illuminating gas supply, and these may be generally classified as follows:

(1) *Booster Service* for supplying outlying territories, congested districts with inadequate mains and similar service. Here the simplicity of arrangement and operation secured through the convenience of gas supply outweigh the probably less costly fuel that would obtain using a producer gas or steam plant. While this phase pertains to the engineering features of gas distribution, it interests the consumer only, insomuch as it exemplifies the utility of the illuminating gas engine.

(2) *High Pressure Fire Service Systems.* The dependability of the gas engine has manifestly received full recognition in being adopted for this important duty, as the two installations in the city of Philadelphia witness.

It is quite plain a gas engine driven reserve pumping station affords a very economical type of equipment in view of the elimination of the steam boiler plant with the attendant standby losses and expenses. In the electric system, i. e., centrifugal pumps driven by electric motors, the "readiness-to-serve" charges, it is apparent, will become an appreciable factor in the cost to provide for this emergency service. While the revenue to the gas supply company may not be directly of any great moment, it is reasonable to suppose considerable advertising advantages are bound to accrue from the greater prestige and publicity given the gas engine.

(3) *Peak Load Service of Electric Systems.* When compared with other items bearing on total cost of power, the fuel expense diminishes greatly with the length of time (in hours or fractions thereof per day) during which the plant may be operated.

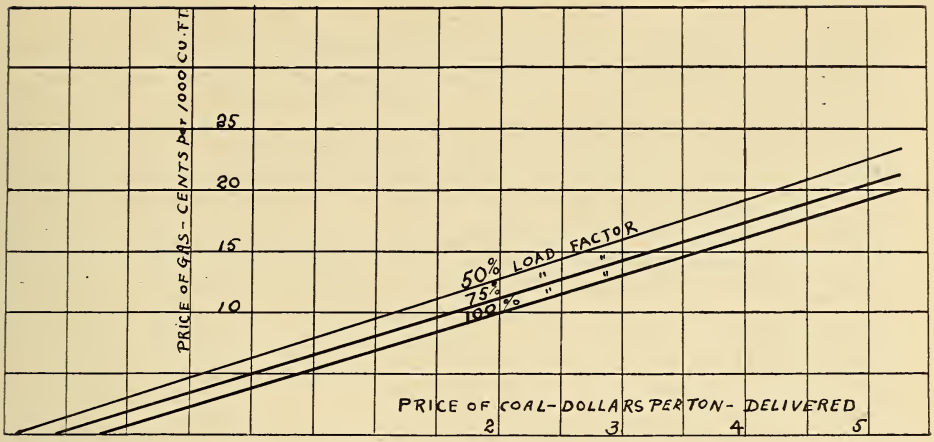


FIG. 1.—COST CHART SHOWING EQUALIZATION OF COST OF ILLUMINATING AND PRODUCER GAS

Allowance is made for operating and capital expense chargeable to producer gas plant. Plants above 200 horse-power in size; coal, 4,000 B.t.u. per pound; gas, 600 B.t.u. per cubic foot.

Similarly, as occurs in the high pressure fire systems, the *readiness-to-serve* expense, including boiler attendants and standby losses which are occasioned by a peak load of short duration, may be thus avoided.

Gas generating plants may in this way assist the steam station in providing for peak demand, and to do so with the least expenditure through the use of gas storage holders. On the other hand, electric storage batteries are prohibitive for this class of service owing to both their high investment cost and upkeep. It may be generally stated that, to-day, storage batteries are being installed in power plants only as insurance of continuity of service. The advisability of employing fuel gas for the peak load will obviously depend upon the true nature of the maximum demand as regards duration and extent.

LIMITED USE FOR CONTINUOUS SERVICE INVOLVING LARGE AND MODERATE POWERS

It will be quite evident from Fig. 1 that with the present charges for illuminating gas much less expensive power may be developed by means of an individual producer installation where capacities of 100 horse-power or more are supplied. In the smaller sizes the labor and maintenance charges of the producer may become more or less disproportionate, such that the total cost of operation may approximate or exceed the result of using city gas. Where power is used in an industry passing the limit of small engines, say above 50 horse-power, there is generally a predominating demand for heat supply in latitudes above 37 degrees. With the exception of small buildings, the heating may be accomplished with the least cost by the use of low pressure steam generated directly from coal. But a single step more and high-pressure steam may be generated with negligible addition in cost. This steam may be applied in a steam engine or turbine, serving as a pressure-reducing valve which gives considerable power as a by-product.

Where a heating load exists, a selection between gas and steam power may only be adequately made after the *"power-steam factor,"* that is, the ratio of the pounds of steam required per hour to the horse-power demand is known. Heretofore, only limited use has been made of waste heat from the gas engine and this has, of course, curtailed its use in many instances.

Recently, cast iron exhaust heaters have been brought out which have satisfactorily withstood the corrosive action of the gases and have comparatively high efficiency in heat transference. It may be safely stated that for every horse-power developed in the gas engine two pounds of atmospheric steam may be obtained from the heat of the exhaust. Should a hot water system be adopted, the jacket heat may also be appropriated and an equivalent of five pounds of steam may be imparted to the heating system from the wasted energy of the engine. Roughly, the following types of equipment would best comply with the *"power-steam factors"* indicated, as follows:

	Based on B.H.P.
Simple automatic engine	40
Small steam turbine	30
Single-cylinder Corliss engine	28
Corliss non-condensing compound engine	22
Complete expansion turbine (bleeding 25 per cent. from receiver)	6
Gas engine (waste heat—jacket and exhaust—used in hot-water system)	5
Gas engine only, exhaust applied to steaming	2

It will be understood, of course, that the latitude, climatic and operating conditions will each in turn affect a choice.

POWER USE WITH HEATING REQUIREMENTS ABSENT OR INDEPENDENTLY SUPPLIED

With the exception of large power stations, which have been previously discussed, the commercial application of the illuminating gas engine finds its greatest demand for the *independent* generation of power of small output.

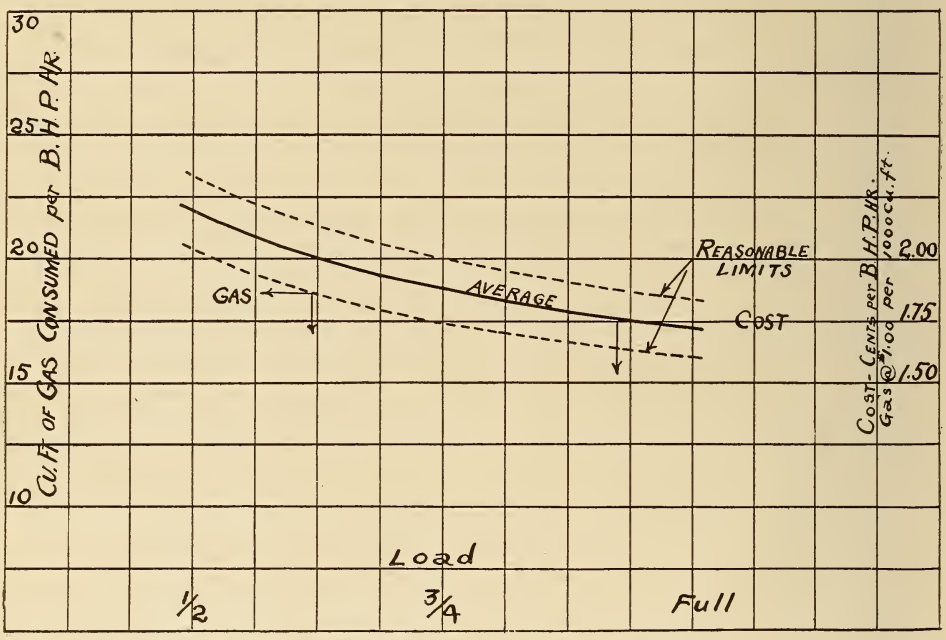
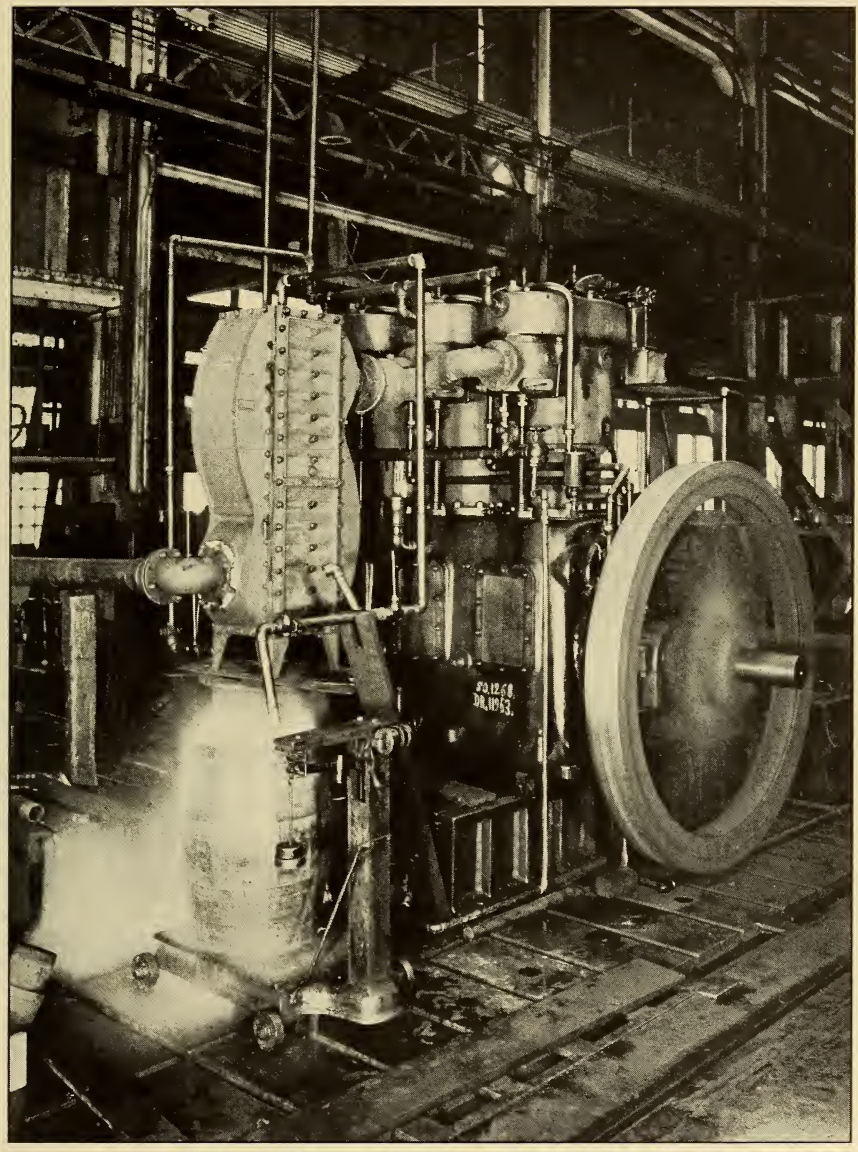


FIG. 2.—GAS CONSUMPTION AND COST PER HORSE-POWER FOR SMALL GAS ENGINES AT VARIOUS LOADS UNDER SERVICE CONDITIONS, USING GAS OF 630 B.T.U. PER CUBIC FOOT

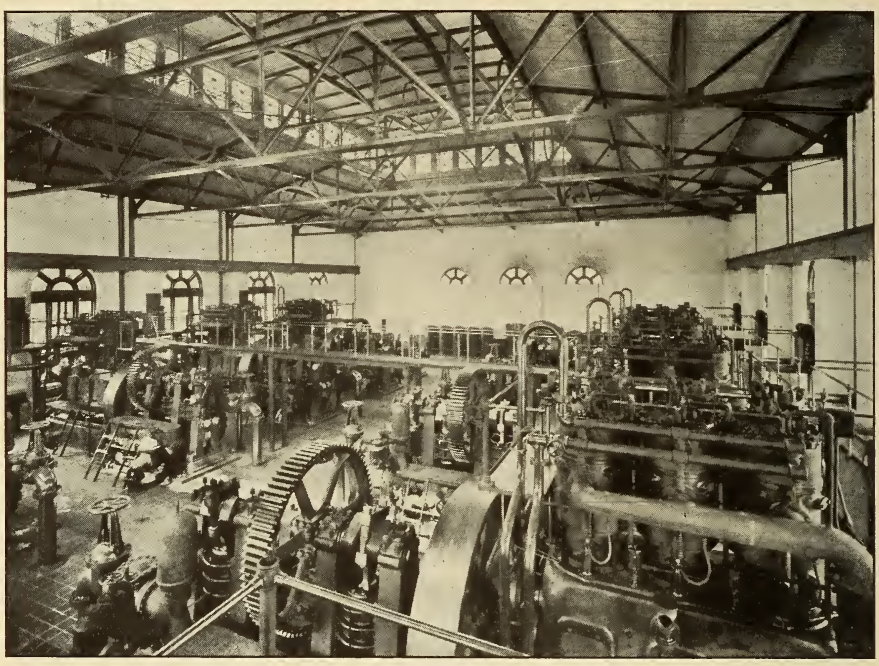
The virtue of illuminating gas power of small capacity lies in its low fuel costs, as exhibited in Fig 2. No definite charge is made for labour, since a small gas engine of proper design does not require the constant attention of an attendant, and, therefore, the engine may be started and stopped and occasionally inspected to insure that all parts are in good condition and adjustment, by whomsoever oversees the general operation of the heating plant and other mechanical apparatus throughout the buildings. In other words, where a well-



TESTING THE HEATING VALUE OF GAS ENGINE EXHAUST

built engine is installed it may be considered for this purpose that the time devoted to the engine is incidental to the other duties which the superintendent or engineer may have to perform, comparable to a large degree with the case of the electric motor. Hence, with a small increase of approximately 10 per cent. for oil, the cost in Fig. 2 practically represents the running expense to the customer. As repairs may be seldom or irregularly made during the year, it is reasonable for a small user to include them in the fixed charges, so that even distribution of this cost may be spread over the entire year. The true cost then will manifestly cover the capital charges and the upkeep of the plant, which may be estimated for purposes of illustration at 17.5 per cent. of the investment. Engines of from 3 to 50

horse-power range in first cost from about 27 to 62 per horse-power. Taking $40 as an average, the annual cost on the above basis ($40 × 17.5) becomes $7 per horse power. This, divided by 8,760 hours, equals 0.8 of a cent per horse-power at 100 per cent. loading factor. The average output of the small engine should approximate 75 per cent. of its normal rating, and, therefore, operating ten hours per day for three hundred working days would produce 2,250 horse-power hours or $\frac{(2,250)}{(8,760)}$ about 25 per cent. of the possible normal development. Consequently, the cost per unit output beeomes 2.2 + 3.2*, or 5.4 cents per hour. It is to be understood, of course, that the cost will vary 10 per cent. to 20 per cent. either side of this average value, which is based on one dollar gas.



A GAS POWER PUMPING STATION

COMPETITION

Interest naturally attaches to the cost of other available power. For small work, 40 horse-power and less, where heating is not a factor, the boiler and producer should be avoided on acount of the comparative inconvenience and nuisance in the handling of coal. Generally, for such conditions, electric supply only remains to be seriously reckoned with. The gasoline engine is omitted owing to the greater fire hazard present and advanced insurance rates, and also for the reason of an oil-fume ladened atmosphere often encountered.

Motors from 3 to 50 horse-power in size vary in cost from $10 to $45 per horse-power installed, depending on whether the service is direct current, 60-cycle, single or three-phase systems.

For an average (10 horse-power) a cost of $22.50 per horse-power erected may be allowed. The fixed burden of electric installation will possibly be lower than in the case of the engine plant, and may be set at 12½ per cent.,* resulting in an ave-

* .8 ÷ 25 per cent. = 3.2.

* Maintenance is undoubtedly much lower for electrical equipment than gas.

rage annual charge ($22.50 × .12½) of $2.81, or 0.321 cents per horse-power hour (100 per cent. load factor).

A 25 per cent. load factor would raise the fixed cost to 1.27 cents. Deducting this amount from the total cost of a corresponding gas engine equipment, we have 4.13 cents per horse-power hour as the gross value, which may be paid for current with dollar gas. But the internal losses of the motor are not included, and, therefore, with an efficiency of 82½ per cent. at ¾-load the gas engine is practically placed on a parity with current at a net value of 3½ cents per brake or shaft horse-power developed.

It is quite true these relations will vary with different conditions, but this example, in a sense, presents the general aspect of their competitive position.

Electrical supply companies, with few exceptions, sell their output on a sliding scale, involving a primary and secondary rate; in other words, a "readiness-to-serve" charge is imposed for the use of the maximum demand. Hence, where the consumer's operations cease during a considerable part of the month, he still continues to pay for service he is unable to utilize. While in the operation of a gas engine, although the owners have the interest on this engine investment to bear, the charge for gas service ceases with a discontinuation of the consumption. In either case there is always a nominal minimum charge covering the cost of inspection and meter reading.

Furthermore, electric companies are in a position to favour large consumers and, therefore, discounts increase with the amount of current consumed, due to the greater economy that obtains in the supply of energy in bulk. Hence, the small power user is obliged to pay proportionately more for electric current. In illuminating gas power no distinction is made in many cities in charges for varying quantities of gas consumption, which must undoubtedly prove very attractive to the small consumer.

Electric current may sell from 1½ to 3 cents per kilowatt hour (wholesale rate consumption) under a favourable loading factor.

The base rates are usually 10 cents per kilowatt hour for the primary demand and range in the neighborhood of 5 and 3 cents per kilowatt hour for the secondary consumption. For requirements equivalent to load factors of 4 per cent. to 10 per cent. the current cost will be from 9 to 6 cents per net horse-power hour, while load factors of 7 per cent. to 23 per cent. can be supplied with current at 7 to 4 cents per net horse-power hour, due allowance being made for motor losses. In gauging the load factors here expresed it must be borne in mind that they are based on the entire elapsed time of the month, averaging 720 hours. In view of the fact that a power load is considered, there is possibility of fluctuating requirements such that the average load may represent only a fair percentage of the maximum demand. For instance, in the case of a 25 per cent. load factor for an 8-hour day service, this would mean that the engine when in service will sustain a load of 75 per cent. of its rating.

QUALITY OF SERVICE

In order that the small gas engine business may prosper, it is very important that the consumers' operations must be reasonably free from interruptions and irregularities. Such results may be insured only through the installation of good equipment of responsible design, and the inauguration and maintenance of definite and regular inspection. Two parts of the gas engine particularly are the cause of trouble if neglected, viz.: the ignition system and the piston rings. As any faults in these parts may be so easily corrected, no reasons exist for failure to obtain continued efficient and dependable operation with a well-built gas engine.

WELDING AS A CAULKING PROCESS

By James Steelman

OXY-ACETYLENE welding is being employed as a means of making perfectly tight a joint which has been made by other means. That is to say, it is being used as a caulking process. Indeed, this promises to be one of its important applications. For example, steel pipe with riveted seams is being applied to the purpose of conducting water under the pressure of a very considerable head. The question of securing an absolutely tight joint is very important. At present, the oxy-acetylene process is not in competition with riveting as a means of making the joints themselves. But it is a method of making the riveted joint a tight one. Again, the seams in the roof of some of the very finest of steel passenger railway coaches depend upon riveting and a supporting bar for their strength. But they are made weatherproof by oxy-acetylene welding. Quite possibly, riveting might be dispensed with and welding alone relied on for the strength of this joint. With that question we are not now dealing. In such cases as the foregoing and in many others, oxy-acetylene welding is an admissible means of caulking.

Soldering and brazing are also methods of securing tightness of joints, but they are at times difficult of application or unsatisfactory in results. Oxy-acetylene welding permits the use of precisely the same material as that in the work itself. This is important for more than one reason. For example, where the finished joint will be subjected when in service to considerable fluctuations of temperature it may be of great importance that the *expansions and contractions* with the new material shall occur in the same degree as with the old material of the work itself. In general, materials expand and contract at rates which vary with the materials. But acetylene welding permits the use of a welding rod of the very same material as that to be welded. Secondly, when diverse materials are involved, there are bad results consequent upon the setting up of *electrolytic currents* in cases in which liquids containing acids in solution come in contact with the seam. The joint may suffer deterioration with the result of occasioning leakage. Thirdly, oxy-acetylene welding permits a strong closure to be made. This is not always the case with soldering. In oxy-acetylene welding, a joint may be effected where the strength is a high percentage of strength of the work itself, even though no difficult annealing operations are carried out.

Caulking by the oxy-acetylene method can be done in the shop or in the field. It can be done prior to final assembling or subsequently. There are exceptional situations, but these are the facts for the bulk of the ordinary cases. Moreover, *oxy-acetylene caulking* is an economical proposition. It is not ridiculously cheap; but, considering the quality of the work, it is economical. For example, the caulking of the roofs of steel passenger railway coaches cost the concern building these cars 4 cents per lineal foot for the labor. The gas expense is estimated at about 1½ cents, making a total of 5½ cents per foot. The material was steel sheeting about 1/16 or 3/32 inch in thickness. On each car a total of about 232 lineal feet of roof joints were made or sealed by the oxy-acetylene process.

VIEW OF A PORTION OF THE 9,000-FOOT BOULDER PIPE LINE CAULKED BY THE WELDING PROCESS

As an illustration of what may be done *in the field,* the work done on the Boulder pipe line of the Central Colorado Power Company may be cited. This line is located near Boulder, Colorado. Altogether, it is about 9,000 feet in length and has a total drop of 1,875 feet. Now a hydraulic head of 1,875 feet produces a pressure of 812 pounds per square inch, if we disregard frictional consideration. It will be seen then that the lower portion of the line would be under severe pressure conditions. At the bases, the pipe line diverges into two branches which serve two 10,500 horse-power water wheels. These are of the impulse type and drive two 5,000 kilowatt-hour generators. At the top, the pipe is 4 feet 6 inches in diameter. At the bottom the diameter is diminished to 3 feet 10 inches. It is

ONE OF THE WELDED JOINTS IN THE BOULDER PIPE LINE

The girth straps are united to the longitudinal strap and the latter welded into a continuous strap 4,000 feet long.

constructed throughout of sheet steel. The wall thickness varies from ¼ inch at the top to 1¾ inches at the base.

Especial interest attaches to the lower portion of the line, because of what took place subsequent to the beginning of actual service. The pipe was shop-assembled into 21-foot sections. Each section consisted of three rings. The joints were made by bringing the edges of the wall together and riveting cover straps in place. There was a single longitudinal joint extending the length of the section. These joints had wide cover straps within the pipe and narrower ones on the outside. The exterior cover strap of each section was a single piece. Four lines of rivets—two lines to each side of the joint—held three thicknesses of metal together. The interior strap was held to the wall by two additional lines of rivets, one to each side of the outer strap. The circular joints were secured by girth straps, also riveted in place. In the field, it was necessary to make girth joints and connect up longitudinal straps. The top longitudinal strap fell short of the pipe section at one end and overhung it at the other. When the field connections were completed, the joints of the external strap came ahead or behind the center line of the corresponding girth straps. The amount invested in the 1.7 miles of pipe line was about a quarter of a million dollars, exclusive of the investment in excavation of trenches, anchorages, etc.

In August, 1910, this line was put into service. It was not long, however, before leaks began to appear. The caulking of the field joints where the 21-foot sections joined each other was ineffective in resisting the tremendous pressures. The water, escaping with the great force, threatened to extend the damage by the action of the sand in the vicinity, the sand being caught up by the water jets and projected onto the rivets. In other words, wet sand blasts were in operation upon a vital part of the work. No effective method was

A LEAKING JOINT UNDER PRESSURE IN THE BOULDER PIPE LINE

known for stopping these leaks; so in November the line was put out of service. The problem then was to find a way of effectively sealing about 200 field joints, 27 of which were in rock tunnel construction. After considerable investigation, the decision was reached to deal with the leaks by means of oxy-acetylene welding.

The problem was to seal the joints of the 21-foot sections of longitudinal strap and thus unite them into one continuous cover plate, 4,000 feet long; and also to seal the joints where

PORTABLE SHELTER FOR WORKMEN WHILE WELDING. THIS HOUSE WAS MOVED ALONG AS THE WORK PROGRESSED

the girth straps connecting sections joined the longitudinal strap. There would be two such joints to every section. When completed, there would be a kind of backbone and ribs three-quarters of a mile long, the whole consisting of a single piece of steel.

It was imperative to get at the work

WELDING A JOINT IN PIPE LINE AT THE ENTRANCE OF THE TUNNEL

at once and carry it on during the winter, otherwise the loss would be greatly increased. In addition to the difficulty involved in the severity of the weather conditions, the location of the work on a steep mountain side at a distance from the town produced serious problems in connection with the delivery of acetylene and oxygen at the point of use. A portable wooden house was set up and moved from point to point, to afford shelter to the men actually engaged in the welding operations. The acetylene was manufactured at a selected point and then piped to the spot where operations were being carried on. Acetylene was piped as far as 500 feet from the location of the acetylene generating plant. In the course of the work, covering a total distance of 4,000 feet, this plant was moved four or five times. The oxygen plant was set up at a separated point, and consisted of generating apparatus and a compressor. The gas was compressed into cylinders and then transported to the point of use on a construction tramway or by means of a stone-boat drawn by a horse. Altogether 18 tons of calcium carbide were consumed in the manufacture of the acetylene; and 23 tons of chlorate of potash in that of the oxygen. From these facts we can get an idea of the extent of the caulking operations. In order to prevent freezing of the water employed in the generators, it was necessary to provide a means of supplying heat, and a steam heating apparatus was used for this purpose.

Three welds had to be made every 21 feet. Altogether, the lineal length of a set of three amounted to a length varying from 30 to 50 inches. We readily calculate then, that a total length of welding was done amounting to about 8,000 inches, of 667 feet. This work was nearly complete in March, 1911. It was performed by one expert welder and four or five men trained by him. The thickness of the straps united ranged up to 1¾ inches. In addition to the bare unions along the lines of contact of strap with strap, it was thought well to add new metal and make fillets where the girth straps joined the longitudinal strap at right angles. Altogether, it is computed that 800 such filled-in connections were made. The whole work, with the exception of some less important welds, was done by the few men in about 3½ months. The general manager of the Central Colorado Power Company at the time when the work was thus about completed expressed himself as follows: "The company is highly satisfied with the work, and feels that without this process of welding it would probably have been necessary to replace 4,000 feet of the heaviest portion of the pipe."

MODERN ROCK-CRUSHING MACHINERY

By John S. Franklin

ONE of the characteristics of modern engineering methods appears in the increasing magnitude, both of operations and of the mechanism by means of which they are conducted. Things have to be done on a wholesale scale to be done effectively, viewed from a commercial standpoint, and engineers and inventors have been obliged continually to increase the dimensions and capacity of apparatus.

Formerly the operation of rock crushing was limited, so far as machinery was concerned, to the breaking up of pieces of moderate dimensions to smaller sizes, and the handling of the larger pieces formed a part of the operation of quarrying. At the present time the demands of industry have changed this state of affairs, and today crushing rolls are in operation which are capable of handling pieces originally weighing as much as fifteen tons, such blocks being reduced to pass a ¾-inch screen or finer.

An interesting installation of such powerful crushing apparatus appears in connection with the production of pure crushed limestone, in connection with the manufacture of basic steel. The annual production of open-hearth steel in the United States has now reached a point of parity with that of Bessemer steel, and in the production of high quality of basic steel it is necessary to use limestone which is free from silica. It is most desirable to provide this limestone with economy, especially if considerable railway hauls are involved, and it has thus followed that the methods of crushing and screening developed by the Edison Crushing Roll Company, of Stewardsville, N. J., become of interest, because of their high degree of efficiency.

For similar reasons, the plant and quarrying methods used by the National Limestone Company at their work near Martinsburg, W. Va., deseve our notice and attention. The superstructure of the plant of this company was erected by W. W. Lindsay & Company, engineers and contractors of Philadelphia. The character of the material in this locality will also claim our consideration.

In the Martinsburg district are located enormous deposits of very fine limestone. Everywhere it outcrops on the surface. In fact, the presence of limestone is a valuable agricultural feature. For a considerable number of years, limestone has been quarried close to the city, if not within its actual limits. A great deal of the rock is highly tilted, so that the mining operations consists largely in the removal of the overlying soil or useless rock and a breaking up of the limestone by blasting operations. The property of the National Limestone Company consists of about 1,000 acres upon which are located four deposits. The one which is now being worked is two miles long and upwards of 150 feet deep. Its width averages about 200 or 250 feet. The stripping preparatory to quarrying the limestone is a very simple matter, consisting merely in the removal by hand methods of a thin layer of soil. The strata stand almost vertical. The edges are much eroded and soon become whitened upon exposure; so that a stripped area presents an appearance not unlike to a mass of monster bones. The irregularity of the upper face of the limestone thus precludes the use of ma-

chine methods of stripping. The mining consists in throwing down sections of an approximately vertical wall. This is accomplished by drilling vertical holes back from the face and blasting down the wall in front of the holes. The ordinary churn drill is employed, a gasoline engine supplying the power. The entire drill rod, including the bit, will weigh about 1,100 pounds. Advance in the rock is made by lifting, turning and dropping the drill. The hole made is 6 inches in diameter. A row of such holes will be put down at a distance of, say, 25 feet back of the face of the quarry, and at intervals of about 20 feet. The depth will be perhaps 160 feet. The blasting is accomplished in two operations. First, about 75 pounds of 50-per-cent. dynamite will be exploded at the bottom of the hole for the sole purpose of creating a cavity of some size. About half a ton of dynamite will now be put in, filling the cavity and reaching up into the undamaged part of the hole. The bottom half of the dynamite will be of the 50-per-cent. strength, say; and the upper half of the 30 per cent. When this charge is exploded, the effect will be to throw the lower portion of the wall out onto the floor of the quarry and permit the sheltered but not displaced upper portion to settle down into the position formerly occupied by the lower portion. This system of blasting can perhaps be used to advantage generally wherever a vertical wall is to be thrown down. It is probably of especial advantage at Martinsburg because of the fact that the strata are there highly tilted. Of course the foregoing details as to depths and position of holes, and sizes and strength of charges, are to be regarded as merely typical.

At Martinsburg, a 100-ton steam shovel is employed to handle the product of the blasting and to load it onto special skip cars. Steel skips are also employed. A very important consideration with the methods used at Martinsburg consists in this. If a stone is not too large for the monster shovel, it will not be too large for the crushing apparatus. That is to say, any secondary blasting of particular blocks has primarily the capacity of the shovel in view. Another big shovel is to be put to work later on. A little consideration will show that the use of the largest size of shovel combined with the capability of the crushing apparatus to take anything handled by such shovels leads to very considerable economies. The blasting expense is greatly reduced, and also the cost of labor. A further and considerable advantage arises from the increased independence of labor conditions.

In connection with the efficient working of quarries such as those in Martinsburg, it is quite important that the arrangements for drainage be thoroughly dependable. From the point of view of economy, it is also desirable that the necessary pumping apparatus be simple and subject to the necessity of only infrequent and small repairs. At these quarries are installed two standard pumps built by the A. S. Cameron Steam Pump Works, New York City. Upon these two pumps alone the management depends for the necessary clearance from water. That confidence is not misplaced is indicated by the experience with the pump which has been installed for some time. The manager of the works reports that this pump has undergone hard service, has handled a large amount of water with ease, has been used day and night for over a year and has cost far less than $10 for repairs in that time. The second pump has been installed only recently and has hardly had time as yet to make its record.

The rock when loaded onto special skip cars—one skip to a truck—is drawn by locomotives to its destination in the crusher house. Including the switches connecting with the Baltimore & Ohio R. R., the railway trackage on the property amounts to 4 or 5 miles. A train for the crushing rolls will consist of perhaps 10 or 15 cars. One of the three locomotives

will draw the train into such position that the rear car is right alongside the hopper which leads to the rolls. When this car has been dumped, the train will be shifted to bring the next car into position, and so on. Because of the character and capacity of the crushing arrangements, no especial care is necessary in connection with the dumping of the skips. The load is simply dumped into the hopper,

A CAMERON STEAM PUMP IN THE LIMESTONE QUARRY

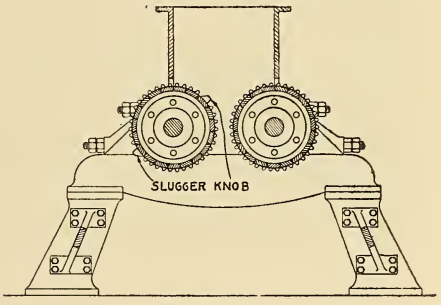
whether it consists of one or two enormous blocks or a mixture of big and little stones. Just over the rolls, a horizontal section of the opening of the hopper is a rectangle of about 7 by 10 feet.

THE CRUSHING ROLLS

The actual crushing is done by a pair of enormous rolls. Each is 6 feet in diameter and 7 feet long. Their cylindrical surfaces are provided with numerous projections or knobs arranged in circumferential and longitudinal lines. All knobs are essentially alike with the exception of those in two longitudinal rows on one of the rolls. The great majority are about 2 inches in height. A circumferential row is in reality an annular rib interrupted here and there. As the rolls are given a rotational movement, the knobs have front and rear faces. These are planes inclined towards each other above. Thus, the forward face is a plane extending upward and backward. The inclination to the cylindrical surface is not a steep one. The other knobs, arranged as already said in two longitudinal rows, are of superior height. Their forward faces are quite steep. These knobs, arranged in two lines diametrically opposite each other, are known as "sluggers." They are prominent, if not the chief, agents in shattering the rock. The two rolls are placed alongside each other. Their circumferential rows are immediately opposite each other. That is, the arrangement is not a staggered one. When in operation

the rolls rotate in opposite directions —towards each other, viewed from above. There is thus produced a kind of V-shaped trough, the sides of which are in rapid motion towards the bottom. When running at full speed with no charge of rock between them, the rolls have an angular speed of about 165 rotations per minute. As the roots of the knobs are 3 feet from the axis of rotation, they have a velocity of about 35 miles per hour. At any given point where sluggers pass, 330 blows are delivered per minute— or 5½ blows per second. As there are 8 or 10 sluggers arranged in a longitudinal row, it will readily be seen that we have here the equivalent of a numerous body of violently active sledge hammers. Furthermore, the sluggers and other knobs operate with the accumulated energy of the heavy rotating weight of the rolls. They weigh, in fact, about 50 tons each. The shattering effect is incredible. It matters but little what is the size of the rock. If it is once fairly in the grip of the rolls, it will be smashed to bits in a few seconds. A large skip load consisting of big and little stones will be so effectively and so quickly smashed to pieces—chewed up, as it were—that one gets the impression that the stones have no chance.

The crushing rolls are an invention of Mr. Thomas A. Edison, and were furnished by the Edison Crushing Roll Company, of Stewartsville, N. J. Each roll rotates with a shaft 21 inches in diameter passed through it. Next to the shaft is a mandrel having an octagonal cross-section. Upon the plane rectangular surfaces thus supplied, the crusher plates themselves are secured by large tap bolts. Ten bolts hold each plate. The plates themselves are 22½ inches broad at the bottom and 3½ feet long. The maximum thickness, exclusive of knobs, is 5 inches; the minimum 4 inches. Sixteen such plates make up the complement belonging to one roll. The number of bolts to a roll is thus 160. All tap bolts have a diameter of 2 inches, except those which secure the slugger plates. These latter tap bolts have a diameter of 2½ inches. All threads are V-shaped. No nuts are employed; the bolts are simply screwed into tapped holes in the mandrel. The plates are of chilled cast iron; the mandrel is of cast iron. The great shaft is reduced to 18 inches diameter at the bearings. The two shafts may be adjusted at various distances apart so as to crush the rock to different predetermined sizes. When brought to the mimimum distance apart, the product of the crushing operation will be sizes ranging from about 4 inches down. In this position the sluggers barely clear the knobs of the companion roll. The rolls may be placed as far apart as 8 feet 8 inches between centers. The product will then be approximately 24-inch and smaller. Six-foot giant rolls readily take care of stones weighing 15 or more tons. In fact, they are able to deal with cubes 7 feet on a side and weighing 28 tons. It will thus be seen that such large crushers as the giant rolls at Martinsburg have a capacity well up to, if not beyond, that of the largest of the steam shovels. The energy of such a pair of rolls rotating at 165 revolutions per minute is estimated in effect at about 4,000,000 foot-pounds. It is important to have this accumulated energy available. When the rock is fairly gripped, both rolls tend to rotate in unison. Because of the enormous amount of work done in such a short time the rotative speed goes down sharply and then slowly recovers itself. The shattering of an



SECTION OF CRUSHING ROLLS

8-ton rock will require perhaps 13 seconds from start to finish. Ten seconds of this time may be required to regain speed. The two rolls are not geared together, but are operated absolutely independently of each other by separate motors. It is supposed that the slugger roll does the greater portion of the work. Probably in the majority of the cases, its speed falls off more than that of its companion. However, they keep pretty well together. The motors fall off somewhat in speed, probably, but the reduction in rotation velocity of the rolls is far beyond what can be accounted for thus. The driving pulleys slip in the belts which envelop them. Considering this slippage, one will not be surprised to learn that the upkeep of belts is one of the chief items of maintenance. The total expense for upkeep is, however, quite moderate. I do not have figures for the plant at Martinsburg, but referring to figures covering the operation of four rolls at the works of the Edison Portland Cement Company, some interesting facts come to light. In the space of two years, these rolls crushed rock from sizes running up to 10 tons to a size capable of passing a ¾-inch perforation. The entire amount thus crushed amounted to 1,024,409 tons. Exclusive of labor, the repairs and replacements cost $8,718.39—an average of $0.0085 per ton. The plate expense accounted for about one-half; the belt expense for about one-quarter.

At the Martinsburg plant the giant rolls are driven by a pair of electric motors, each having a power capacity of 200 horse-power. When it is understood that the energy demanded at the most intense instant may arise as high as 3,000 or 4,000 horse-power, it will be seen that it is very necessary to store up energy in the rolls—just as with the ordinary fly wheel. The maximum demand continues, however, for a very short interval—perhaps half a second. Remembering that at this moment the rotational speed has been considerably reduced, we are prepared

VIEW OF THE EDISON CRUSHING ROLLS, WITH A PORTION OF THE CASING REMOVED

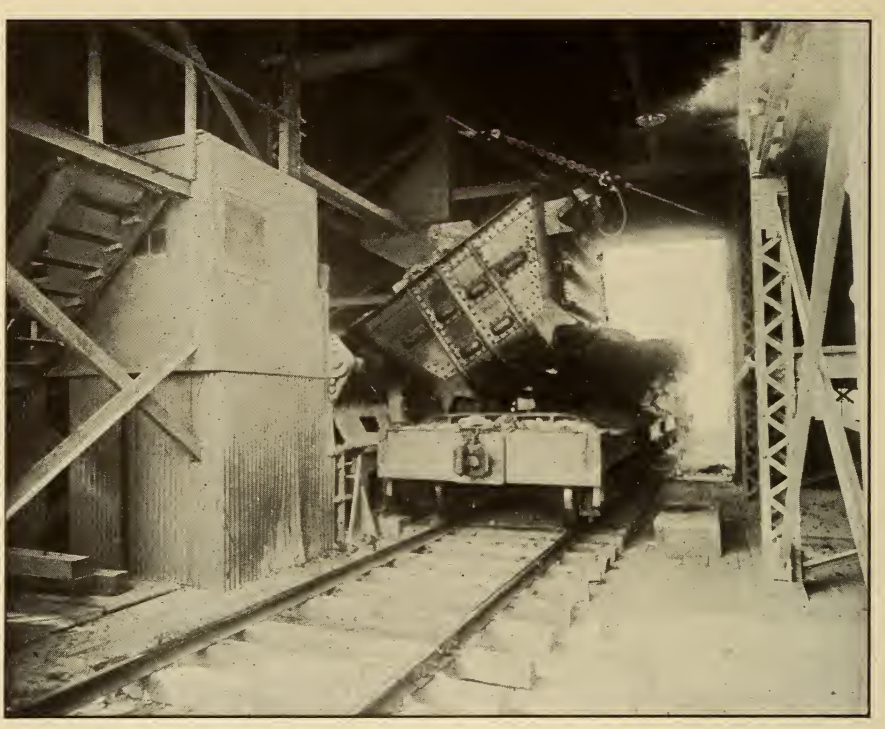
to learn that the crisis of the crushing operation is accomplished by one or perhaps two blows of the slugger knobs. Immediately before and after the single blow of a row of sluggers, the demand for energy is much less. The belts which connect motors and driving pulleys are 24 inches in width. The motor pulleys are 32 inches in diameter and those on the rolls 96 inches, so that there is a speed reduction in the ratio of 3 to 1. As the rolls are operated in opposite directions, the upper side of one belt and the lower side of the other are tight. One belt has, then, a slack lower side. An idle roll is used to support this. The roll pulleys are mounted directly on the roll shafts, one on either side of the crusher. The successful use of electricity for this service is ample proof of its adaptability for work where shocks are to be expected and taken care of. A satisfactory solution of such problems is ordinarily or often to be sought in the use of apparatus having fly-wheel characteristics. These Edison rolls are successfully driven by motors totaling only 400 horse-power because of the great weight and substantial character of the rotating mechanism. It is doubtful whether the shocks of a rolling mill are proportionately equal to those experienced with these rolls. The demand for energy at the moment of crisis may be 8 or 9 times the capacity of the driving engines.

What the capacity of such rolls as those at Martinsburg actually is no one probably knows. It is far beyond the capacity of the remainder of the plant. In fact, the output of the whole works is determined by the capacity of the conveying arrangements which transport the product of the giant rolls to the summit of the screen house. At present this capacity is about 1,000 tons per hour. It is probable that the capacity of the rolls is several times this.

The present practice at the Martinsburg plant is to use the rolls for crushing to a size at least as small as 7 or 8 inches. There will, of course, be quantities of rock of all sizes below, including dust. It is all valuable, provided it is properly classified. So then, the problem subsequent to the great crushers is largely one of screening. But not altogether. If a very considerable percentage of the smaller sizes is desired, then supplementary crushing will be employed as part of the procedure. Edison rolls of reduced dimensions may be employed on this service. At Martinsburg the giant rolls are the only crushing apparatus at present in use. Consequently, the smallest sizes are produced in relatively small amounts. That is to say, the product is now largely confined to the sizes used in the open-hearth process of steel making and the blast furnace production of pig iron. To these may be added the sizes used for railway ballast, road making, etc. It is proposed ultimately that this plant shall include additional rolls and screening apparatus in order to produce considerable amounts of the smallest sizes. These sizes are employed in the manufacture of glass and agricultural fertilizer.

The screening apparatus now in use and projected are all stationary devices. No perforated plate rotates or shakes. The Edison system provides a series of inclined perforated sheets arranged at intervals vertically. The rock falls through these by the simple force of gravity. In order to secure the amount of screening desired, quite a number of plates are necessary. In consequence, the screen house is a tall affair. Power economy is secured, because of the simplicity of the movements required. Thus, for example, the rock which comes from the giant rolls is transported in bulk to the top of the first screen house—the only one now built. This operation, if we except that required for a short line of conveyor, represents the total power requirement of all the screening now taking place at this plant. That is to say, a single lift of the material in bulk effects the screening.

When the rock comes from the giant rolls, it falls into a hopper, de-



A CARLOAD OF LIMESTONE ROCK BEING DUMPED INTO THE HOPPER OF THE CRUSHING ROLLS

livery from which is controlled by a smooth roll driven by power whenever it is desired to discharge rock. An inclined railway runs from a point beneath the discharge opening to the top of the crusher house near by. There are two tracks for the greater portion of the incline. Both tracks merge, however, below the discharge point mentioned. Two large steel skips are hoisted and lowered by means of double cables running over sheaves arranged above the summit of the incline and descending to a duplex winding drum located at the ordinary level. One skip descends empty while the other ascends under load. Eighteen, or perhaps twenty, tons of rock can be carried at once. The rear axles of the skip cars are provided with an additional exterior wheel on each side. These run on a short length of track arranged at the top of the incline, and forming in effect a continuation of the main track. The track of normal gauge, however, makes a turn in a vertical plane. The effect of these arrangements is that the rear axle continues on up the incline, while the front axle turns off. In consequence, the skip is dumped over its forward end. The screening operation from a lower point of view is now complete. Gravitation—overcome in the hoisting—supplies the movement necessary. The holes in the Edison screen are oblong, the principal diameter being in the general direction of fall. As the rock slides on the screens and falls through, the various sizes are segregated and diverted. It is expected ultimately to perform a supplementary screening operation in a second screen house whereby certain sizes will be rather minutely divided into sub-grades. Two lines of belt conveyor are to be added—one will carry rock from the basement of the first screen house to the top of the second; the other will return oversizes to be crushed in secondary rolls. In the second screen house, gravitation will again supply the moving force to carry the rock over the screens.

As already stated, W. W. Lindsay & Company, of Philadelphia, erected the superstructure crusher and screen houses, which are of steel with corrugated iron roofing and siding. The screen house has a total height of about 108 feet above the surface. There are, in all, seven floors, the longest distance between floors being 22 feet from the sixth to the seventh floor levels. The portion containing the lower floors has a much larger plan area than the higher part. The skip hoists are carried on trusses from the hopper pit under the rolls up to and into the tower-like portion of the crushing house. The lower structure has a plan area of about 40 × 47 feet; above, the plan area is about 22 × 38 feet. When it is considered that exclusive of the car there is a concentrated moving load of about 18 tons to be provided for on the incline and on the horizontal at a considerable elevation, it will be seen that the requirements for strength are severe. Further, the practice of suddenly dumping the load of rock and letting it drop down through the various stationary screens imposes the necessity of resistance to shock and vibration.

By using supplementary Edison rolls, it is quite possible to crush rock so that there will be little or nothing larger than the ¾-inch size. This has been proved at the works of the Edison Portland Cement Company, as has already been explained. It will readily be seen, then, that these machines are competent to the breaking up of ores and the like. The ore or other product of the mine can be fed to giant 6-foot rolls in blocks as large as the biggest steam shovels handle. The product of these rolls can then be passed through supplementary crushers of the same general type, the result being material much of which is very fine and none of which is larger than the ¾-inch size. The economy in blasting expense must be of a high character where the product of the primary blasting needs reduction only to steam-shovel capacity. The considerable elimination of dependence upon unskilled labor thus accomplished is likewise important. The Edison crushing roll promises to be, in fact, a piece of mining apparatus of the highest value. We are informed that 3,500,000 tons of stone was crushed in the Edison Giant Rolls in 1911.

EFFICIENCY IN WATER FILTRATION

THE necessity for the use of some apparatus for removing impurities from water supply, both for household and industrial purposes, is now generally conceded. Nearly all sources of supply for places of any importance are too closely associated with possibilities of contamination to be accepted as proper to be used without some attempt at purification, and the subject is one which occupies the attention of engineers and technical men in an increasingly important manner.

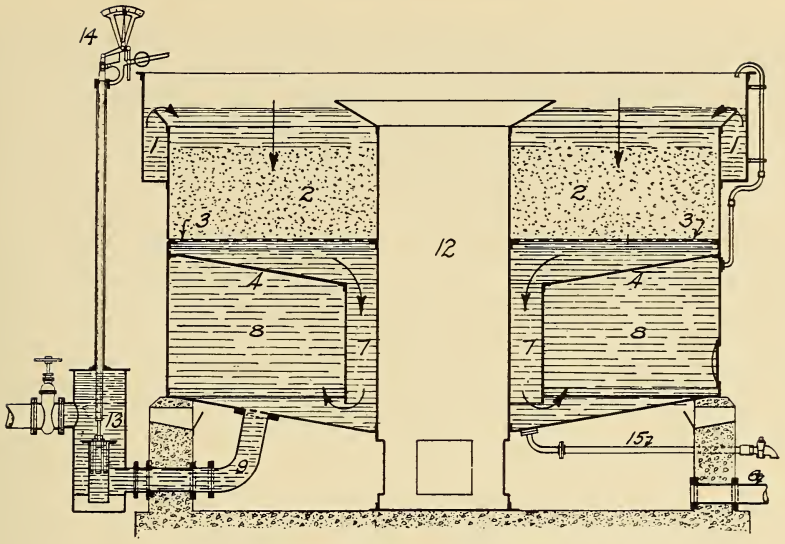
It is now well understood that the impurities in water, other than those actually in chemical combination, may be very effectively removed by proper filtration, and methods for accomplishing this result have been in operation for a number of years. These systems generally depend upon the use of a bed of sand of sufficient thickness to compel the water to percolate slowly through its depth, the impurities in mechanical suspension being retarded upon the sand, while a bacterial coating also forms upon the surface of the filter bed, and effectually holds in itself the further bacteria in the flowing water, the resulting water being purified both from bacteria and from suspended earthy matter.

In practice, two important matters connected with the operation of filters of this kind have developed themselves. In the first place the rate of filtration, when the flow is caused solely by the action of gravity, is necessarily slow, so that filter beds of very large area are required to deal with the supply of a town or city. In the second place, the accumulation of the impurities separated from the water acts to retard the flow until it becomes necessary to clean the surface of the filter bed in order to avoid entire stoppage of the filtration.

The question of the increasing rate of flow through the filter beds, in order to keep dimensions within reasonable sizes, has been met by the use of the so-called "mechanical" type of filter, in which the action of gravity is supplemented by additional pressure, thus increasing the rate of flow and permitting a corresponding reduction in dimensions for an equivalent capacity.

The question of cleaning the surface from the accumulation of material separated from the water by the filtering action has been treated in various ways. In the older, open sand bed filters, the area has been divided into a number of sections, so that one portion might be thrown out of service at a time, and the surface of the sand bed scraped clean by workmen with proper tools and wheelbarrows. This method is open to many objections, since it is most undesirable to have such material handled by manual labour, apart from the slowness and cost of the operation. Such a method also acts to disturb the filter bed to a certain depth and break up the mass of filtering sand. In any case, such a process was unavailable in the closed type of mechanical filter, and some mechanical method of cleaning became necessary.

One of the earliest plans attempted to clean filters of the mechanical type was that of reversing the flow of water and forcing the current in the opposite direction from that of the



SECTION OF REISERT FILTER WHILE FILTERING

regular filtering operation. It was assumed that such reversed flow would carry off the accumulation of material upon the surface of the filter bed and restore it to active service. In practice, however, it was found that this method was not sufficient to remove the matted impurities, because it was impossible to force the water economically up through the filter bed with enough pressure to clear the clogged bed. It was therefore attempted to aid in the operation by the use of some form of stirring device, to break up the surface of the filter bed and permit a better passage of the wash water through it. Such devices consisted of revolving rakes with long teeth, extending into the filter bed, these rakes being revolved by mechanical power, as by belt connection to line shafts, or by connection to independent motors. In any case, such apparatus involved the expenditure of considerable power and included certain disadvantages. The use of circular motion required the filters to be of circular form, which did not always permit of the most advantageous use of the space available. The employment of rakes also caused the formation of channels in the filter bed, making paths of less resistance to the flow of water than existed elsewhere, and permitting the passage of raw water too freely through these portions of the filter, and giving an imperfectly filtered product.

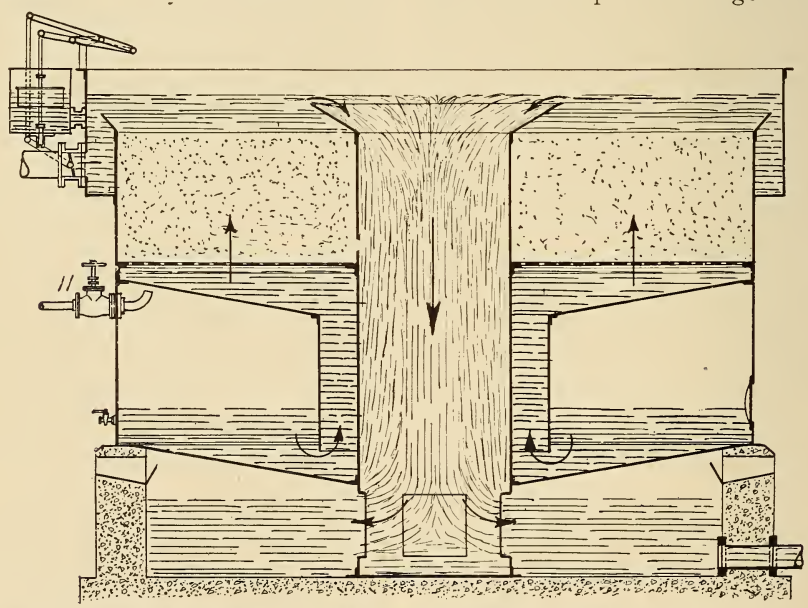
In the course of time manufacturers began to use compressed air for the agitating of the filter bed. The practice was, and, with one exception, still is, to blow the compressed air directly through the filter bed, while at the same time, as formerly, the wash water is pumped directly through the filter bed. This is a great improvement over the old method, in that it permits the filters to be of rectangular cross section as well as of circular cross section, and it also does away with other disadvantages that resulted from the use of rakes or other mechanical agitating devices. However, the disadvantage still remains that the process of washing is necessarily slow because for economical reasons the size of the wash pumps must be kept within practical limits.

The former method of backwashing the filter bed with raw water has to a great extent been abandoned and in modern filter constructions the filters are washed with filtered water.

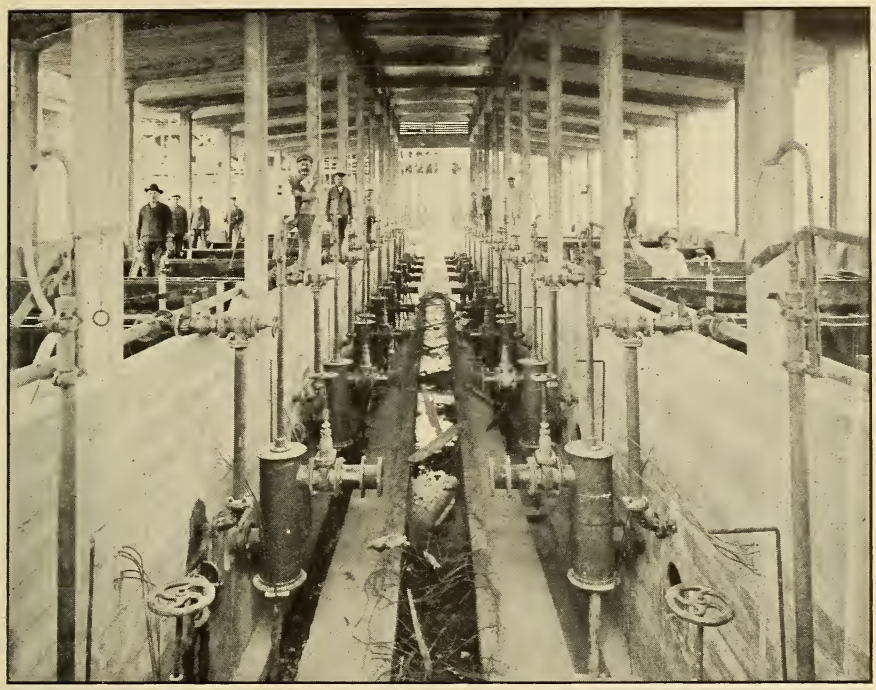
In the ordinary type of filter plants the filters discharge clear water into the clear water well, and the wash water pumps pick up the filtered water from these clear water wells in order to force it back through the filter bed for washing. This calls for the installation of an independent pump unit for washing the filters and entails a considerable item of cost for power for washing the filters. This item is all the more considerable because the pumps have to be operated through very appreciable intervals varying from 8 to 20 or 30 minutes per day, and sometimes even longer.

In Germany, Hans Reisert, who had for many years devoted his talents to the numerous questions of water purification, was one of the first to abandon all mechanical stirring devices and adopt compressed air for agitating the filter bed. In his early filters the air was blown directly through the filter bed as described above. More recently, however, he has perfected a new filter in which the filter bed is washed with clear water which is driven through the filter beds by means of compressed air. By this method the compressed air is not permitted to come in contact with the filter bed at all. By using compressed air as the propelling force for driving his wash water through the filter bed, it is possible to wash the filter at a much higher rate of speed, and on account of this higher rate of speed there is effected an intensive washing which efficiently cleans the filter bed of all sludge in a minimum of time.

When a filter bed is washed by simply reversing the flow of water through it, the speed of the water passing through the filter bed is so slow that while the water breaks up the filter bed, the heavier particles of sludge are able to fall through the rising water into the bottom of the filter. In this manner the sludge may permeate the entire filter bed, so that it will become almost impossible to wash it out with the simple aid of the back-flowing water. For these reasons in standard practice, when air is blown through a filter bed, the air is passed through the bed before the back flow of water is started. In this manner the air separates the deposit loose from the sand and breaks up the sludge without



SECTION OF REISERT FILTER DURING OPERATION OF WASHING. REISERT AUTOMATIC WATER PURIFYING CO., 30 CHURCH STREET, NEW YORK



FILTER PLANT UNDER CONSTRUCTION. FELDMUHLE PAPIER UND ZRLLSTOFFWERKE AKTIEN GESELLSCHAFT, ODERMUNDE

disturbing the filter bed, so that when the water is started through it, it is able to carry the particles through the filter bed and over the sludge gutters. Under the Reisert system of washing, however, the wash water passes through the filter bed at such high velocity that all particles, of whatever size, are carried over the wash water gutters.

The construction which permits the propelling of the wash water by means of compressed air, as indicated above, is shown in the accompanying cross section drawing of a rectangular Reisert filter. It will be observed that the upper part of this filter resembles very closely all other standard types of mechanical filters. The raw water is distributed by means of a trough extending the length of the filter, while on either side of the longitudinal axis of the filter are provided wash water troughs over which the wash water overflows and is carried to the sewer. The filter bed, however, instead of resting on a solid bottom, in which is incorporated a strainer system, as is used in other filter plants, rests on a perforated bottom, below which again is a tight bottom through which extend a number of vertical pipes, open both at the top and the bottom. These pipes extend down into a basin, which normally is filled with the clear water which has passed through the filter bed. Beneath the tight bottom is an air system or manifold which permits the air to be uniformly distributed under the tight head. This air manifold is connected with an air receiver of sufficient size to furnish air for entirely displacing the water in the wash water basin with compressed air at sufficient pressure to balance a column of water equal to the height corresponding to the distance from the edge of the wash water troughs to the bottom of the wash water basin. The clear water outlets are so constructed that it is impossible

for the clear water basin to empty itself by syphoning or by other means. In this way the wash water basin is always filled with sufficient water for washing the filter bed. When the filters are originally designed, the size of this wash water basin is determined from the character of the impurities carried down in the water, and contains enough water to thoroughly wash the filter bed once.

In order to wash such a filter, it is only necessary to have available sufficient air at the proper pressure to displace the wash water in the wash water basin with air. When it becomes necessary to wash the filter bed, the clear water outlet is closed and the air valve is opened. This admits compressed air under the tight head, against which the compressed air presses, and, rapidly expanding, forces the water out of the wash water basin upward through the vertical pipes, through the perforated plates, and then through the filter bed. The velocity of the wash water in going through the filter bed is comparatively high, so that the filter bed is thoroughly broken up and the wash water reaches every part of it. The deposited impurities on the filter bed are carried off with the wash water and overflow over the wash water troughs to the sewer. Care is taken then by means of suitable indicators by which the operator can tell when the air is nearing the bottom of the pipes, so that the air can be turned off before the vertical pipes are unsealed. In this manner no compressed air passes through the filter bed and its disturbance is absolutely prevented. When air begins to come out of the indicator, the operator knows that the entire available amount of wash water has been driven through the filter bed. Then the clear water valve can be opened. The air in the

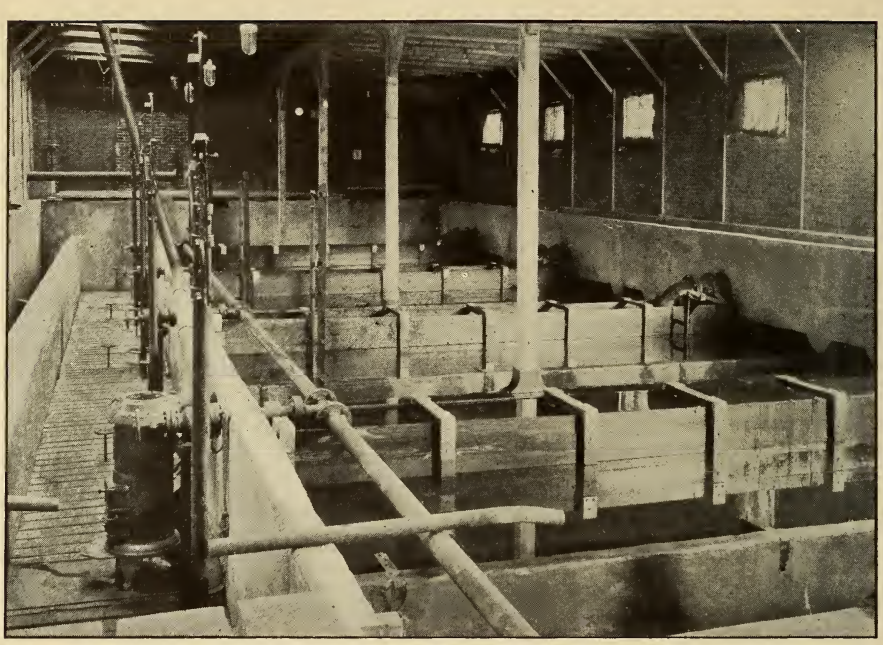
COMPLETED BATTERY OF REISERT FILTERS AT THE PAPER AND CELLULOSE MILLS AT ODERMUNDE, NEAR STETTIN

wash water basin is released by means of an air-relief valve as the clear water begins again to pass through the filter bed and into the wash water basin.

The space of time required for washing the filter bed is remarkably short. Since the piston of compressed air which is driving the wash water upwards through the filter bed has a cross section equal to the cross section of the filter, and the air itself expands with great rapidity, attaining a velocity 33 times that of water under the same pressure, it is really only a matter of seconds before the wash water basin is emptied. It has been reported that such filters have been washed in 20 seconds, and 30 seconds may safely be taken as the mean time required for washing. It will be readily seen that at the instant the washing operation is ended the filter bed is full of filtered water and when the raw water begins again to pass downwards through the filter bed it follows after this filtered water, so that a filter will begin to deliver clear water immediately after washing. This can be attributed also to the efficient manner of washing without disturbing the filter bed or allowing the suspended matter deposited on the filter bed to fall through to the bottom. On this account it is never necessary to filter to waste after washing, as is so often true in the case of other types of filters.

REISERT FILTER PLANT AT THE KOSTHEIM CELLULOSE AND PAPER WORKS. CAPACITY, 480 CUBIC METERS PER HOUR

The first of this new type of Reisert filters installed in Germany were put into paper and cellulose mills. A notable installation is at the Feldmuhle Papier und Zrllstoffwerke Akt. Ges., Odermunde, near Cavellswich, Stettin. The source of the water at this place is from the river Oder, which at times is exceedingly dirty, so much so as to be quite unfit for the making of white paper. The filter plant installed at this place is shown in one of the illustrations. It consists of 20 units, having a filtering area of 140 square feet each. The plant is designed to filter 6,720,000 gallons of water per day of 24

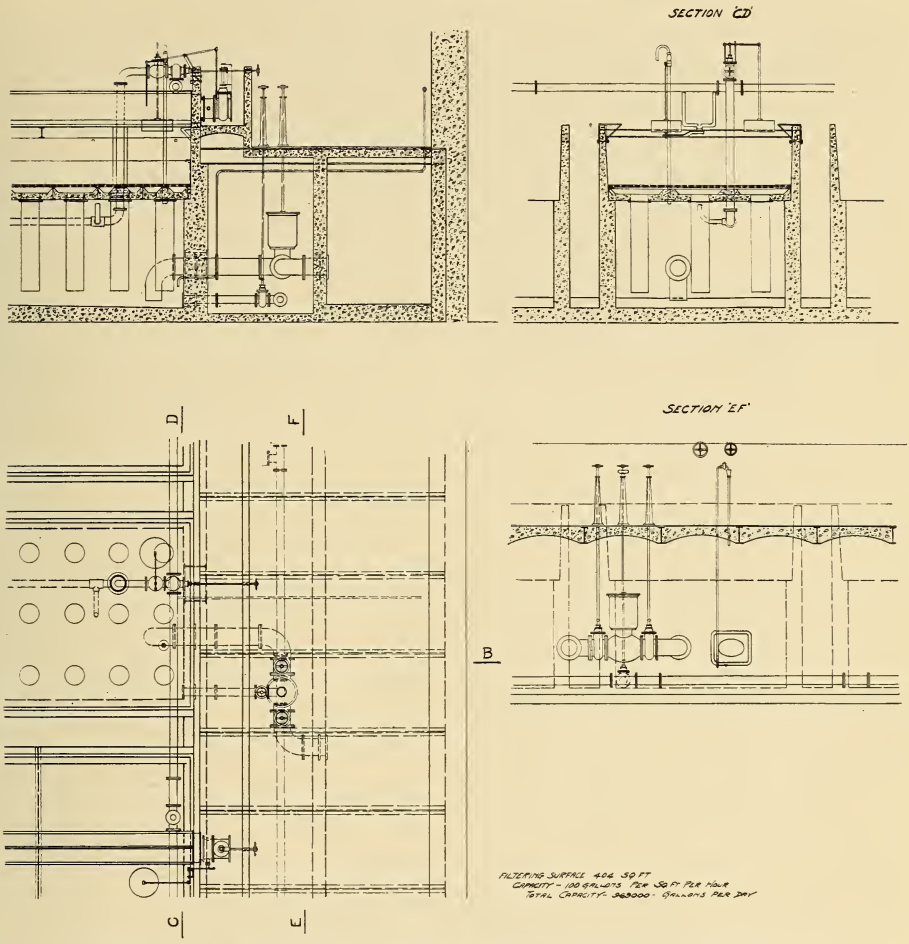


BATTERY OF FOUR REISERT FILTERS PURIFYING RIVER WATER FOR FACTORY USE AT THE WORKS OF M. VAN DELDEN & CO., GRONAU, WESTPHALIA. CAPACITY, 300 CUBIC METERS PER HOUR

hours, and the filtration is perfect for the purpose designated, so that it is possible to make the finest grade of paper with this filtered water. The different units are washed in the manner already explained. It is reported by these manufacturers that the washing consumes only a fraction of a minute, and that the impurities deposited on the filter bed are entirely removed. Immediately after washing, the filters begin to deliver a clear water, so that no appreciable interruption in the flow takes place. Owing to these conditions, the attendance required is reduced to a minimum.

Another notable installation is at the Kostheim Cellulose and Papierfabrik, at Kostheim. This paper mill takes its water from the river Main, a river which, during rainy periods, carries down very large quantities of suspended matter. The problem of clarifying and purifying is further complicated at this place because in the immediate neighborhood of the paper mill and upstream from it there is a considerable discharge of waste water from paint and chemical factories and other industrial plants into the river. Nevertheless, the Reisert filters are able to deliver perfectly clear water, entirely suitable for all the processes of manufacture at this mill, and, as in the case of the Odermunde filters, the attendance is found to be a minimum, while the interruption in flow after washing is practically zero. This plant consists of 8 units, which have a total capacity of 127,000 gallons per hour.

The first municipal installation of these new filters which has been made is one which is now under course of construction at the city of Barmen. The city of Barmen had in former times installed slow sand filters, but the results obtained from them were not commensurate with the large filtration areas required, and the high cost of operation. The authorities, therefore, decided to replace their old sand filters with some modern type of mechanical filter. In order to be in a position to select the



ARRANGEMENT OF REISERT FILTER PLANT FOR THE CITY WATER WORKS OF BARMEN, PRUSSIA

best possible filters, they conducted a series of experiments extending over a period of one year. These experiments were under the supervision of the Royal Experimental Institute of Berlin. Various manufacturers of filters in Europe were invited to build trial filters, the results from which could be compared, while working under exactly the same conditions. Hans Reisert built a filter of his new type. This filter was a small one of circular cross section, and was 5 feet in diameter and about 9 feet high. The filter bed used consisted of white quartz sand and was 31 inches deep. This filter was designed to deliver about 46,000 gallons of water per 24 hours. The filters were operated under the strictest supervision of the Royal Experimental Institute, and at the end of the trial period it was found from the records that the Reisert filters had made the best showing. They had shown the greatest economy in washing, both as to time and amount of wash water required, the highest efficiency in washing, the greatest simplicity in operation due to the elimination of all moving parts and wash water pumps; also the lowest cost of maintenance, since the cost of repairs, etc., was practically nothing.

The result of these experiments was that the city of Barmen has

contracted with Hans Reisert for the construction of a new filter plant having a total capacity of 12,573,000 gallons of water per day. The filter plant now being constructed consists of 13 units, each of which is 12.5 meters long by 3 meters wide. The filter bed itself rests on two perforated plates having perforations about 25 millimeters in diameter. Between these two perforated plates is a brass wire cloth screen of suitably fine mesh. The distance from the perforated plate to the top of the wash water trough is 1.03 meters. The thickness of the filter bed is 0.78 meters. The tight head beneath this perforated plate is supported by eighteen 200 millimeter I-beams, so that the tight head itself has a thickness of about 200 millimeters. In this tight head in each filter unit are 16 troughs, 100 millimeters deep, in each of which is set a row of 3 vertical pipes, open top and bottom, and each of a diameter of 260 millimeters. This makes a total of 48 pipes extending down within about 75 to 150 millimeters of the bottom of the wash water basin, which has a decided slope in the longitudinal direction. In the case of these Barmen filters, the effective depth of the wash water basin is 1.5 meters. This gives a total capacity for the wash water basin of 56.25 cubic meters of clear water, or about 14,900 gallons. Each filter unit has a filtration capacity of about 967,200 gallons per 24 hours, figured at the rate of 100 gallons per square foot per hour, which is nearly at the rate of 105,000,000 gallons per acre per day. Taking an extreme case, where the filters would have to be washed twice a day, which is a contingency that will seldom occur, we find that the ratio of wash water to clear water delivered is almost exactly 3 per cent. Since during the greater portion of the year it is only necessary to wash the filter bed once per day, this ratio will fall between 1½ and 2 per cent.

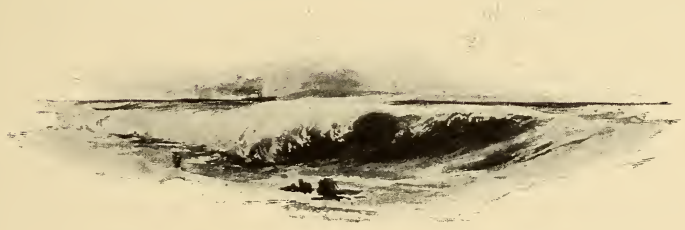
The raw water is delivered to each filter unit by means of a raw water trough centrally located and extending along the long axis of the filters. The 13 raw water troughs open into a raw water channel 0.9 meters deep, into which the water flows by gravity from the reservoir.

The filter units are so constructed that there is a wash water gutter approximately 12½ meters long and .50 meters wide on either side of each unit. This makes a total of 14 wash water gutters, all of which connect into a wash water gallery, which in turn is connected to the sewer. Each filter unit discharges into a clear water well through a 250 millimeter diameter pipe. Each filter unit is provided with a rate controller, depending for its operation on the difference of pressure between the inlet and the outlet side of the controller. The raw water entering the filters is automatically regulated by means of a float and balanced valve, so as to maintain a uniform head above the filter bed. The air manifold consists of 4-inch, 3-inch and 2-inch pipe, with elbows turned up from the header. The air is furnished from two receivers connected with two motor-driven belt-connected compressors, each 2 meters in diameter by 4 meters high. Each wash water basin is provided with a 100 millimeter diameter drain pipe, and with 1½-inch air relief pipe, and each unit is provided with a standard manhole. The construction of the entire plant, with the exception of the raw water troughs, which are of steel, is of reinforced concrete. The entire filter plant is housed in one-story concrete building with truss roof. It will be seen that the only machinery necessary in this plant is the motor-driven compressor outfit just described. For this reason it will be readily understood that the plant is run with the very least possible attendance and has a minimum of maintenance cost and depreciation charges.

The development in filtration apparatus which has here been described is an interesting example of

the manner in which high efficiency is attained by considering that portion of the operation which offers the greatest opportunity for improvement. The operation of filtering water has been understood for a number of years; and when the work is to be conducted upon a commercial scale, there appears to be small opportunity for increasing the efficiency of the process beyond the rate of flow, which is limited by the separation of the impurities.

There did appear, however, a serious source of loss, and consequent cause of inefficiency in the operation of cleaning, both in the actual cost of performing the work itself and in the loss of service of the filter during the cleaning operation. Instead, therefore, of trying to improve and perfect the filtering operation, in which already a high degree of efficiency had been reached, the problem of reducing the waste of effort and time in the cleaning operation was attacked, and a consequent advance made.



LOOKING FORWARD

EDITORIAL NOTES ON IMPENDING DEVELOPMENTS

Controlling the Mississippi

When the actual construction of the Panama Canal was studied by engineers of experience in the special departments of work involved, it became evident to all that the chief problem to be solved was not the cutting of a channel through the narrow portion of land forming the isthmus, but rather the control of the irregular and torrential flow of the Chagres River. The fact that practically all the drainage of an extensive and steep watershed had to reach the sea through this stream, together with the climatic conditions which included much rainfall, rendered this portion of the problem a matter for serious consideration, since upon its practical solution depended the success of all the rest of the undertaking.

It is now well known that the creation of Gatun Lake, providing an extensive reservoir, into which the sudden increase of the volume of flow could be received without making any serious variation in level, was the true method of controlling the Chagres River and of converting it not only into a well regulated supply of water for the canal, but also of providing ample hydraulic power for all operative purposes of the canal.

Now that the work is nearly completed, it may well be considered if the lesson thus learned may not be applied, without delay, to the solution of a similar problem within the borders of the United States, and possibly save for the country losses which exceed the cost of the construction of the entire waterway at the isthmus.

The destructive floods of the Mississippi River are of frequent occurrence, and it seems as if the existing methods of protection against them by the construction and maintenance of levees and bank reinforcements, are inadequate, and even antiquated, when considered as sole defenses against the river floods. The lesson at Panama would indicate that the true method of treating the problem of the Mississippi would be the creation of a number of artificial lakes similar to that at Gatun, and for a similar purpose, their location and size to be determined by topographical and commercial considerations. A number of such lakes, produced by damming the stream at points where the accumulation of water could be controlled, would enable the excess of water to be stored and held back over such areas as would produce but moderate changes in level, even during the season of maximum flow, and thus protect the lower reaches of the river from danger and render the existing levees ample to insure safety. The stored water, as at Panama, would be available for regulated power development, and also enable the desired flow to be maintained during the season when low water would otherwise prevail.

The importance of considering this matter at the present time appears because the United States Government is now in possession of a complete organization, administration, and engineering equipment for the execution of such a plan. Instead of disposing of the extensive equipment so soon to be finished its work at the Isthmus, the rational and efficient thing to be done would be its transfer to the Mississippi Valley and its

immediate use in the creation of a series of regulating lakes which would remove permanently all further danger of flood damage while conserving the power of the great river for useful service. The most inefficient thing which could be done would be the disposal of the Panama equipment and the dispersal of its personnel while such an evident and immediate task is awaiting its services.

The Concentration of Effort

One of the most serious sources of waste in industrial operations appears in the dissemination of effort in directions in which it can be of little or no possible use. In the days before high-power guns and accurate marksmanship were general, it was often considered advisable to use "scattering" charges, with the idea that such a widespread discharge should, in haphazard fashion, hit something coming within its general range. It is evident that such a method, whether used in connection with gun discharge or anything else, is most wasteful in principle and in application, and it is becoming apparent that modern methods are being directed toward the use of a minimum of effort highly concentrated, and directed precisely at the point upon which its action is desired. It is upon this principle that all modern cutting tools are designed, and it is this principle which should govern all efforts which make any pretensions to high efficiency.

Probably one of the most effective applications of this idea appears in the various forms of apparatus for the utilization of extremely high temperatures in industrial operations; such, for example, as in the oxygen-acetylene blowpipe, or in the electric furnace.

The ordinary idea of a high temperature is associated with the production of a great amount of heat, and many persons fail to distinguish between temperature and quantity of heat. It is entirely possible to produce a large amount of heat, making everybody and everything in the vicinity intensely hot and uncomfortable, and yet not produce an exceedingly high temperature at any point. The oxygen-acetylene blowpipe, however, causes an exceedingly high temperature to be produced in a very concentrated area, enabling refractory materials to be fused, metals cut or welded, and other high temperature effects to be produced, while, at the same time, objects a little further off are unaffected, and the workmen themselves experience no inconvenience whatever.

Such an operation is an excellent example of high thermal efficiency, because of the very small waste of heat involved. The heat generated is concentrated to produce a very high temperature within a very limited area, and this area is that in which the work is to be done, so that no more heat energy is expended than the work requires. When one observes a furnace emitting immense quantities of radiant heat, and perceives men exposed to temperatures which can be endured for but brief periods, it is immediate evidence that much waste is going on, and that the operation is essentially inefficient. The boiler furnace, together with the surfaces, which, in spite of careful jacketing with insulating material, are raising the temperature of boiler and engine room far above the comfort point, spell inefficiency by just so much heat as is escaping, while the combustion engine, in which the heat energy is evolved directly in the cylinder where it is to do its work, shows its efficiency by reason of the small amount of heat perceptible in its vicinity.

We all know that when a large burden is to be supported it is necessary to spread the support over a sufficient area to keep the unit load within safe limits, and, on the contrary, we also understand that when a powerful local effect is necessary, the area of effort must be kept down to that in which the action is desired.

It will be found that in many industrial operations, very many actions cover far greater areas than those upon which the effect is directly desired. Just in proportion to the ineffective dissemination of effort, the inefficiency is indicated. Concentration upon the very point to be reached is the essential element in efficiency, while anything which acts to spread the effort over a wide area is to be avoided. There is an old expression for inefficiency which is contained in the saying that an undertaking is "spread out too thin," and this, by inversion, indicates that the true secret for efficient action is included in the word "concentration."

Rational Steel Working

The art of cutting metals has been made the subject of elaborate scientific research, with the result that feeds, speeds, form of cutting tools, and improved high-speed steels for tools have been worked out most carefully and effectively.

The problem, however, includes more than one element, and it is possible that sufficient attention has not been paid to the other part of the question, that is, the character of the material which is being cut. Ordinarily a material of construction is selected primarily with respect to the service which is demanded of the finished product, and this having been determined, the proper machines and cutting tools to give it form are provided. Sometimes this is the best which can be done, but it is no uncommon thing to see in the machine shop some slow and difficult cutting operation being conducted upon a hard and resistent material which might have been rapidly and easily done had the subject been composed of some more impressionable stuff. This leads to the inquiry as to whether certain operations are not now being conducted in a sequence which does not make for maximum efficiency, and that the better plan would be to use materials which are soft and workable, so to speak, until all machining operations are completed, and to defer the hardening and completion of the resistance to wear until a later stage in the process.

It is now beginning to be understood that the old operation of case-hardening wrought iron by a superficial application of carbon, producing a hard skin upon a soft material, may be very materially extended, and that by employing a soft steel of low carbon content a workable material may be used for articles ultimately requiring a high degree of hardness. It is practicable to bring fully machined articles of such soft steel up to a carbon content of more than one per cent. by a subsequent carbonizing process, this effect extending to a depth of an inch or more, and by proper heat treatment produce deep hardening of the highest degree without affecting either form or finish of surface. This means that it is not only the art of cutting metals which is to be considered, but also the art of providing suitable metals to be cut, and that in the machine shop of the immediate future the processes of machining will be materially modified and their efficiency greatly improved.

Apart from the improvement in the efficiency of machining operations by providing soft steel as the material to be worked, there is the important consideration of the lower first cost of this material over that of the higher carbon steel otherwise necessary for many machine parts. The machine builder will manufacture his own high carbon steel, and make it only where he wants it upon the portions of the soft-steel parts of his products. This he can readily do even now, and there is every reason to believe that such an order of procedure will, before long, become the accepted method of manufacture, and that the older plan will simply be inverted, and that the working of steel will be immensely improved simply by doing things in the more rational order.

Engineering English

The increasing scope of engineering work has brought about with it the natural demand for clearer and more specific use of terms relating to individuals and operations, and some discussions which have taken place in technical societies and public prints have emphasized this matter.

It is evident that simple and unrestricted names are no longer sufficient to convey clear ideas, and yet it does not seem advisable to follow the suggestions of some reformers and coin new words to differentiate things, some of which have long been associated with names in common use. Thus, the word "engineer" is used both for the professional and scientific man and for the operator who has charge of machinery, either in a manufacturing establishment or a commercial or residence building, and in some places it is also used to designate a mechanical workman or machinist, and is coming into use in connection with supervising and administrative work. Efforts on the part of professional men to coin new words for some of these applications have been unavailing, possibly because they expected the other men to accept the new titles, and in any case it is not easy to get the general public to use unfamiliar words.

A more important matter, and one which has not been given the attention which it demands, is the use of old and well understood words to mean new and different things, without any qualifying terms to show just what is meant. Electrical engineers have done this to an extent which seems hardly warranted by the circumstances. Thus, to an electrical engineer a "motor" always means an electric motor, regardless of the fact that long before the electric motor came into use or demanded a name there were numerous other motors—steam, hydraulic, gas, pneumatic, etc. —in use, these all being commonly designated by the proper qualifying adjective, both in writing and talking. In like manner various kinds of accumulators, hydraulic and others, were well known, but the electrical engineer continually uses the word "accumulator" wholly to mean what is popularly known as a storage battery. Even such a crude expression as the "motor drive" is not infrequently used to mean a machine driven by an electric motor, and similar indeterminate usages of words might be indicated.

In view of the rapidly increasing differentiation of all kinds of mechanical operations, it seems as if some more specific method of writing and speaking might be encouraged, and in this respect the practice in the French language might be considered. As Lieutenant Willcox has said, in the introduction to his admirable French-English technical dictionary:

"Where we, in English, are frequently satisfied to apply the class name to each of the objects or things of one and the same class, the French will invariably modify this class name by some adjunct limiting or defining its application. The result is to force the substitution of a description for a name."

This may take one or two more words to say what is intended, but that is what a name is for, and the time and effort required to use a clear and unmistakable term will generally be found much less than the time and effort consumed in explaining afterwards just what is really meant. Many a difficult situation may be avoided by the use of moderate care in the employment of technical terms.

Engineers have been charged with slovenliness in the use of English, and this may be because they are so clear in their own minds as to what they mean that they assume an equal familiarity with the subject on the part of others, but it is never a mistake to be clear and definite in the use of words to impart ideas to others, and there is such a thing as inefficiency in the use of language, as in many other things.

Gas Producers

It has often been cause for comment among engineers that most obvious opportunities for improvement in mechanical appliances remain unperceived for a long time, and frequently come into operation because of the observation of some one wholly unconnected with the department of industry under question. Surprise that an improvement was not thought of long ago frequently follows some important development, and it is often painfully apparent that progress is delayed because of the repressing influence of precedent.

An excellent example of this appears in the manner in which the gas producer has slowly been developed in the face of existing operations along similar lines. It took a long time for gas engineers to observe that the blast furnace was not only a smelting furnace, but also a gas producer, and it was not a gas engineer who first called attention to the immense volumes of power gas which were being thrown away from the furnace head. In the meantime specialists were endeavouring to perfect the fuel gas producer, and encountering most serious difficulties in handling and removing the clinker formed from the non-combustible portion of the fuel. The laborious and difficult work of "barring" was found to be imperfect, while mechanical devices for keeping the charge in agitation were not altogether satisfactory. All the time there were in operation in different parts of the world great gas producers, consuming not only fuel in which there was a considerable portion of non-combustible, but also being fed with earthy matter entirely foreign to gas production. These great gas producers had no trouble whatever with the formation of clinker, but the gas engineers paid no attention to these plain and practical examples before their eyes, because these most efficient devices were not called gas producers, but bore the name of blast furnaces.

The reason that the blast furnace has little or no trouble with clinker, notwithstanding the large proportion of non-combustible contained in the ore, lies in the fact that there is also added with the charge a certain proportion of limestone, which, acting as a flux, converts the non-combustible content of the furnace into a mass which is fusible at the temperature of the combustion zone, so that it melts and may be drawn off in a liquid state.

The material charged into a blast furnace may be divided into three parts: the iron, which is reduced to the metallic form and discharged in a melted condition; the carbon, which combines with oxygen to be discharged as carbon monoxide and dioxide in the gaseous form; and the non-combustible elements of the fuel and ore, which are fluxed by the limestone and discharged in molten form as slag.

With this example before him, operating successfully on an immense scale, the gas engineer has finally directed his attention to the possibility of adding the proper portion of limestone to the charge in a gas producer, thus making it correspond in action to a blast furnace without the addition of any iron ore, the result being that all the non-combustible material in the fuel which formerly gave so much trouble in the formation of clinker is separated entirely in the form of a liquid slag, and may be tapped off readily whenever desired, without interrupting the operation of the gas producer at all.

The United States Bureau of Mines has recently conducted a series of tests upon such a gas producer, showing that it is entirely possible to operate a gas producer of this kind with a fuel of low grade, high in non-combustible, and remove all the clinker and slag in the liquid form by the mere addition of sufficient limestone to flux it, the gas being of excellent quality, containing more than 30 per cent. of carbon monoxide and less than 2 per cent.

of carbon dioxide, either with or without the addition of steam. Continuous runs as long as 100 hours have demonstrated the fact that the producer is kept clear of clinker, and there appears to be every reason to believe that the fluxing method for removal of slag is as fully applicable to the gas producer as it always has been in connection with the furnace for smelting iron.

Mechanical Management

So much has been said of late about scientific management in manufacturing establishments that it may be desirable to look ahead a little and endeavour to see just what departments of productive activity are really in line to be managed according to the methods thus advocated. In general, it seems as if the lines of work capable of such organization and conduct are those from which, in the course of a comparatively short time, the skilled mechanic may be almost wholly eliminated. Repetitive processes, operations which may be described in instruction cards or planned out wholly in advance by some one other than the individual by whom they are to be executed, are the very ones from which the element of individual judgment may be almost entirely removed, and therefore are next in line to be turned over to inanimate and almost entirely automatic, machines. The things which the machine cannot do to advantage are those which are not performed twice alike, and into which the immediate and varying judgment of the man who is really doing the work must enter. Such work is becoming of less and less importance from the commercial point of view, and the real mechanic, according to the old-time standard, is almost to be classed with the artist, the man into whose work his own personality enters so largely as to make it impracticable for him to tell anyone else how to do it as well.

When a piece of work demands the private judgment of the operator to any material extent it is hardly adaptable to any system of intensified production, such as is desirable for the methods of modern scientific management.

It follows that one of the important things in connection with the introduction of such a plan lies in the systematization of the product itself, to render its manufacture practicable under the new conditions. If, however, such a study is given to the repetitive character of the product, it will be found, in nearly every instance, to lead to the introduction of such mechanical methods as to take practically all discretion out of the hands of the operative and convert him into a machine tender, his speed being determined by that of the machinery with which he is associated, and he himself becoming practically a part of those machines.

Such a condition of affairs has already been reached in some departments of industry, and there is every reason to believe that it will be extended. Its growth means a change in industrial conditions which will well bear examining, and it seems as if the present interest in scientific management is really only an intermediate and passing stage in a far deeper transformation in manufacing conditions.

The kind of work which, if done by men, must be done in a mechanical manner, is the kind of work which should not be done by men at all; and it is for the advancement of the race to have it taken out of the hands of human beings and transferred to inanimate mechanism. This means that men must be given a higher and better kind of work to do, work which involves the use of their heads as well as their hands, and the men who have hitherto performed purely mechanical work qualify for the newer and higher class of activity. The Suez Canal was dug with human hands and wicker baskets; the Panama Canal is being excavated by the steam shovel, the hydraulic jet, and the

dump car, under the guidance of men of intelligence and judgment.

When, therefore, any department of industry is studied with a view to the introduction of scientific management, it is suggested that the study be carried on to the next stage of technical progress without lingering at the transitory phase, and that a direct effort be made to arrange the product and the processes in such a manner as to permit the employment of a limited number of highly intelligent directors, and of such a number of machine tenders as may be necessary, relegating everything which can possibly be performed in a purely mechanical manner to a machine and not to a man.

Action at a Distance

It is evident that something will soon have to be done to check the congestion of individuals crowding from one part of a city to another and interfering with each other both physically and mentally. In nearly every great city there is an increase continually in transport facilities, followed naturally by an increase in size and population of the commercial and other buildings which are served by those facilities. It is the old story, facilities create traffic, and then traffic demands more facilities, and so the whole system keeps jacking itself up in rachet fashion and there is no apparent end or relief in sight. Under these circumstances it is evident that we are on the wrong track, and that something else will have to be done if any kind of satisfactory growth and development is to be attained.

The fundamental difficulty in the present system seems to be the idea that it is necessary for individuals to come into close proximity to each other if they are to transact business or to exchange ideas, or make plans under which they are to work in any co-ordinated manner. It is not surprising that such an idea should have become firmly ingrained into the minds of men in past ages, when there was no other means of meeting or exchanging ideas than that of personal contact. With the modern development in mail facilities, in the extension of the telegraph and submarine cable, and especially of the telephone, this idea might seem to be modified, and to a certain extent this has been the case, but at the same time there is a vast amount of running to and fro and increasing knowledge by means which are really crude and primitive when compared with those which are even now at our disposal.

The extent to which it is really unnecessary to see people face to face has been demonstrated by the enormous extent to which the telephone is used both for local and for long-distance conversation. All kinds of business is transacted over the telephone, and without it not one-tenth of the present rapid, really high-speed business could be carried on. Nevertheless, we have every day before us the example of crowded trains, both on the surface, in the air, and underground, people crowding, hustling, and jamming together to get *to* each other, when what they really want is only to get their ideas, phrased in words or arranged in plans without the real necessity of their persons being within reach at all. It is evident, therefore, that if some means of sending thoughts to a distance in such a shape that they could be co-ordinated perhaps by several, instead of by a single conversation at a time, and in connection with such certainty that one could know exactly with whom one was talking, and could receive such intelligent responses as one would expect to get if one were face to face with the speaker, that it would be unnecessary for many people to travel to and from their work at all, and all that would be necessary would be for them to be placed in connection or communication with the parties with whom they were to deal and carry out the entire day's work without moving from their homes. This idea

relates only to conversation, but there are many things which require to be laid out and examined, such as drawings, plans, correspondence, tabular matter, and things of that sort. These, however, can easily be sent, certainly more easily than the person himself can carry himself with them, if proper facilities were provided. Apparently the most available means for transporting such material nowadays is the pneumatic tube. This is in use between branch post office stations and the main central station, and there is no reason why it might not be so extended as to be as available for everyone as the present lamp post or pillar box for mailing letters is for the collection of mail and its transmission to the other terminus. It may be said that it is desirable to know with whom one is talking or dealing, and that a face to face conversation is in many cases absolutely essential. This may be true, but it does not follow that face to face conversation need mean that the two bodies should be in close physical proximity.

Already methods of transmitting portraits by telegraph have been devised, and it is not at all impossible that before very long, when the telephone call comes, there will appear with it the face of the person who is talking, so that the speaker might be readily identified, not only by the voice, but by the visage of his companion, as accurately as if he were in the same room with him. If, then, the face and the voice and the words and the writing or the plans and drawings can be transmitted far more rapidly and with less difficulty than the physical transport of the individual, the latter would seem to be the primitive and roundabout way of doing things, and the former should soon become considered the normal and legitimate way of transacting business. What this would mean is readily evident. The great crush and crowding back and forth in our great cities between the residence and the business section would be diminished and reduced to a minimum, and most of the difficulties already avoided, so that the present facilities would be ample for all the transport that would be required under the new system. What we need is not more railway track, nor subways, nor means of transporting human bodies, but far greater facilities for transmitting the intelligence and material, so that a man in charge of many business interests might sit in his study and communicate accurately, rapidly and effectively with them all far more successively than he could by passing from one office to another, attending one board meeting, another committee meeting and generally endeavouring to convey his own body where he really needs to convey only his own ideas and words and thoughts.

It will be said that one of the principal difficulties in this connection is that of the terminal connection, and this is doubtless so. This was the difficulty which delayed the introduction of the telephone, and it has been truly said that the modern telephone switchboard and exchange was itself as great an invention as the original speaking telephone. It required both of them in order that the proper facilities and advantages of the entire apparatus could be utilized. As a matter of fact, this question of terminal facilities is the principal difficulty in connection with the transport of individuals. There is little or no trouble in transporting people several hundred miles at high speed; the real difficulties appear when the distribution of the individuals at the terminal is attempted, and this is growing worse and worse all the time, because it is still being done after the same primitive fashion as obtained when railroads were first operated. It is practically the same problem in all instances, and as soon as efforts are turned toward the proper utilization of the facilities which are, in the main, already available, just so soon there will appear a relief.

An excellent sample of the way in which such a development has already taken place appears in military matters. Formerly the commander led his troops into action, and his personal example often had much to do with the manner in which the attack was made; to-day he occupies some post of observation, from which he can perceive the entire field or receive reports from many points, and conducts the battle by telephone far more effectively than if he were actually present at the front. The great commanders of business, it is true, conduct their plans from offices which are not always readily accessible, and employ the telegraph, the telephone, and all the mechanism of administration to enable them to command the field of operations. It is only necessary so to extend this method of action at a distance as to permit it to be applied more generally and effectively in ordinary affairs.

Before the telephone came into use, certain large establishments possessed the luxury of a private telegraph wire, with special operators, and the advantages of such means of communication were highly appreciated. With the advent of a complete telephone system, both local and long distance, these facilities have become common, and it is certain that present commercial and manufacturing operations would come to a standstill, at least for a time, if telephonic communication were to be cut off.

The widespread introduction of far greater facilities for immediate and effective communication would act to produce a decentralization and a reduction in necessity for transport congestion which would be most desirable, permitting manufacturing to be conducted in desirable localities, both as regards power generation and with respect to residence advantages for operatives. Many sociological questions would thus settle themselves, the administrative capacity of the direction would be capable of increased efficiency, the operatives would be enabled to lead happier and more healthful lives, and the rapidly accelerating congestion of the large cities would be checked to an extent which would render existing transport facilities abundantly capable of meeting the requirements.

Electric Power in Agriculture

Until recently the customers for the electric power station have been looked for either in the manufacturing cities or in the development of local factory sites near the source of power generation.

It is now appearing, however, that much of the work on the farm may well be done by electric power, and that the motor which receives its current from some hydraulic station, miles away, may do much work on farm service to great advantage, and that it will pay to run mains along many a country road to supply farm machinery with the power formerly obtained either from animal effort or by local engines of some kind.

One of the most important applications of electrical power in agriculture is certain to be for irrigation purposes. It is estimated that there are at least 300,000,000 acres of land in the West which receives an insufficient supply of rain, and which, to be cultivated to advantage, must have some kind of artificial water supply. Much of this land is so situated that it cannot be effectively irrigated by gravity supply from mountain streams, but the power of these streams may well be utilized to generate electricity, which in turn, transmitted to the country side around, will provide power to draw water for irrigation from local artesian wells.

Pumping for irrigation, drawing water from the underlying strata by means of artesian wells, has been done in many localities by means of power derived from windmills or from gasoline engines, but the former power is unreliable and irregular, and the latter involves the handling of fuel, and the provision of local stores of supply. Many such power plants

have been replaced by electric motors as soon as current has become available, and it is becoming evident that there is here a large market for current, and an important element to be considered in the location and development of a hydroelectric station.

Until recently the farmer has been obliged to conduct his work with power of the most expensive kind, the exertion of human or animal muscle, consuming more costly fuel than any machine, even when in actual operation, and requiring support and care during a large portion of the year during which there is no service possible. Any kind of mechanical power is superior to animal power in this respect, since a large portion of the operation charges may be cut off during the winter season, while horses, for example, require as much care and consume as much food when idle as when effective. The use of mechanical power in agriculture has other advantages, however, such as the ability to concentrate effort where needed, both as regards time and space, enabling work to be done within time limits which permit seasons and markets to be met, in a manner impracticable if dependence has to be placed solely upon animal power.

Local steam power plants involve the difficulties included in the transport of fuel and water, and both of these are often scarce and costly at the time and place when power is most demanded. The great advantage of electric power lies in the fact that transmission lines may be run almost anywhere, and that roads for hauling fuel, or pipes for conveying water, are eliminated, and that the machine and its motor may be placed close to the work to be done, while power is consumed only during the period of actual service.

When electric current is available on the farm its presence will be certain to lead to the introduction of many mechanical appliances which would otherwise be impracticable. Much of the dirty work about the farm buildings may be done by vacuum apparatus, while machinery for cutting and handling feed, for milking, washing, and separating becomes available as soon as current to drive the motors may be supplied. The great need on the farm is some approach to the use of power which has long since been general in other departments of industry, and when this fact is appreciated it will be seen that an enormous opportunity for the production and sale of electric energy is offered.

It has been said that the general use of the telephone has revolutionized home life on the farm, and it is doubtless true that such a means of abridging distance, so far as communication is concerned, has done much to remove the loneliness which formerly existed. It must be also realized that the wire which carries power may well exceed in influence the wire which carries only the voice, and before very long the real energy of the man on the farm will be measured, not by his physical strength alone, but by his ability to use manufactured power, generated under most advantageous conditions, and delivered to him precisely where it is needed. It is well understood in the modern manufacturing establishment, that ordinary labor is one of the most expensive things which can be employed, and that everything which can be performed by power should be taken from the man and done by the machine. It is on the farm alone that the older and more primitive conditions yet largely prevail, and this has been both because of the individual character of most agricultural operations and because there has been little or no effort to provide a supply of manufactured power for farm service.

Two things are evidently coming which will make immense changes in the method of creating new wealth from the soil. One of these is the replacement of the individual farmer by the association of ownership possible only by the creation of corporations for the conduct of the work upon a sufficiently large scale to warrant

the use of modern mechanical methods; the other is the realization of the manufacturers of power that the broad area of the country offers a greater market for power utilization than exists in any concentration of factory plants in and about a great city. When power is available on the spot it will be used on the spot, and it is one of the great advantages of electricity that it may be made where natural power is available, and then sent to points where it is most needed.

In addition to the varied uses of electricity in the power field of agriculture, it is certain that the general introduction of electric lighting, both along roads and in dwellings, will do much to transform the country and to diminish danger from fire. When to this is added the possibilities of the employment of electric traction, both for passengers and for farm products, it will be seen that the whole subject takes on a national importance. It has been said that much of the idle land in the United States is unused because of its remoteness from the railways, and that it does not require a very great distance from the railroad to render a piece of good land unprofitable. When, however, a few miles of electric railway, running alongside of the country road, may be made to act as a feeder to the trunk line steam railway, there will be opened up for productiveness and profit many thousands of acres of land at present unproductive.

It is by such broad applications of electric power that the rapidly increasing demands for subsistence will be met in the closely approaching future, and with such an extension of power to the development of the land there will come increased opportunities for the investment of capital, not only in electric power stations, electric lighting systems, and electric traction lines, but also in corporations devoted to the exploitation of the land in an intensified manner comparable to that which already obtains in manufacturing industries.

STREET LIGHTING

THE PRINCIPLES OF STREET LIGHTING

THE demand for efficiency in all departments of industrial activity extends to the production and utilization of artificial lighting, especially for public places. For this reason the Bulletin recently issued by the Engineering Experiment Station of the University of Illinois, containing researches upon street lighting by Messrs. J. M. Bryant and H. G. Hare, is especially useful. Some extracts from the general portions of this bulletin are here given, while reference to the publication itself will give useful information concerning methods and costs.

This bulletin is designed to be of assistance to central station superintendents, and to the general public in selecting the proper lamp and fixing the charge for the same. It is also designed to be of value to the illuminating engineer and to the manufacturer, and in clearing up, or perhaps in preventing misunderstandings, which so frequently arise between municipalities and power companies. These misunderstandings, being usually the outcome of imperfect knowledge of the effectiveness and imitations of ordinary street lighting units, may readily be prevented if specifications and contracts be made definite and clear.

Many contracts are based upon the rates charged in cities of about the same size for the same class of service, regardless of the comparative operating cost of the installation in each case. Many companies do not compute the cost of any one particular branch of their service, but are satisfied if their total yearly balance shows a profit. Other companies, while knowing the cost of operation of the street lights, are still governed by the prevailing rate in similar cities. Thus it is that some companies may furnish the light to the city streets at an actual loss, but are compensated for this loss by special privileges in other branches of the service. It is believed that fewer misunderstandings would arise between the consumer and the company if each branch of service received its proper compensation.

The same type of light will not serve equally well for the illumination of all classes of city streets; and certain accepted standard spacings of lights can never produce adequate and economical street illumination.

Probably the most familiar form of illuminant is the flame. At least, this is the earliest historical form. In the flame, the light is produced by small particles of carbon being brought to a temperature at which they will unite with the oxygen of the air. The heat which gives to these particles their incandescence comes from the union of the various compounds in the combustible with the oxygen. If the flame is cooled in any manner, the carbon will deposit in the form of soot before it reaches a sufficient temperature to burn. If enough air be mixed with the gas formed by the heated illuminant to consume the compounds, an almost non-luminous flame results. Thus the alcohol flame is nearly non-luminous; as is also that of the oxy-hydrogen flame and the Bunsen burner. It is well known that non-luminous flames may be made luminous by the introduction of some foreign substance which need not necessarily be consumed; of such character is the Welsbach burner.

In the Welsbach burner, another

interesting phenomenon takes place. If the substance being heated is of a certain character, which is represented by carbon, a combination of colors is obtained for a given temperature. This is known as white light. If, however, the substance be some one of the metals, certain of the colors will be more pronounced—i. e., not all substances give off the same color when heated to the same temperature in a flame. This phenomenon is known as selective radiation. Use is made of this in the newer forms of illuminants in producing more light for a given amount of power or of illuminant. In the Welsbach burner, thoria and seria are spread upon a thin web of heat resisting material. These compounds, when heated to the high temperature of the gas flame, give off a much greater amount of light than would be given by carbon at the same temperature. Many other metals display this property to a greater or less extent. In this field lie the recent advances in the development of arc lights.

In the incandescent lamp, light is produced by a fine filament or wire of some material, heated to incandescence by a current of electricity. Formerly all such lamps were made with filaments of carbon. These were followed by metallized filaments, and later by tantalum and tungsten, the latter being now used in the form of a drawn wire. All of these lights have their filaments in a vacuum to prevent rapid oxidation of the material, and also to prevent the heat from being conducted away from the filament as rapidly as it would be in air or any dense gas. Such lamps are made for house lighting and street lighting.

(*a*) If two pieces of conducting material be connected in an electrical circuit with their ends touching, and these ends be separated slowly, a spark will be seen between them. If the voltage of the circuit be sufficient, portions of the terminals will be burned away, forming a vapor between them. This vapor is in itself a conductor, and current will continue to flow, even though the terminals are rather widely separated. Light will also be given off from the electrodes and the arc stream, thus giving the arc light.

In the earlier forms of arc lamp, plain carbon rods were commonly used for the terminals, or electrodes, as they are called. The voltage to be used across a given lamp, and the current necessary, are so determined for each type as to produce the proper characteristics. The old direct current open arc lamp required about 50 volts and took 9.6 amperes. This lamp was known as the "full arc" or 2,000 "nominal candle-power" lamp. A "half arc" lamp using 6.6 amperes, known as the 1,200 "nominal candle-power" lamp, was also used to a considerable extent. In any given type of lamp, the amount of light and the consumption of the carbons depend upon the current used and the size of the carbons. The light given off by an arc light proceeds partly from the electrodes and partly from the vapor or arc stream.

(*b*) In the direct current open arc, most of the light comes from a crater formed in the positive electrode. The upper electrode is made positive to throw most of the light in a downward direction—i. e,. in the lower hemisphere. Only about five per cent. of the light comes from the arc stream. The voltage across such a lamp must be increased when the arc is lengthened, but not directly in proportion to the distance between the electrodes. This is due to the fact that nearly a constant value of electromotive force is consumed in vaporizing the electrode material. Since any energy used in the arc stream produces but little light and lowers the efficiency, it is desirable to use as short an arc as possible without cutting off too much of the light. A long arc is also more difficult to maintain steady on account of the influence of air currents. The elec-

trodes in such an arc are consumed rapidly; the positive being consumed about twice as fast as the negative. From 1.5 to 2 inches of positive electrode are consumed each hour. Such a lamp must be trimmed each day—i. e., the electrodes must be replaced, entailing expense in labor and material.

(*c*) The rapidity of the consumption of the electrodes in an open arc is due to their oxidation in the air. In order to lengthen the life, or number of hours of burning, of the electrodes, and decrease the expense due to trimming, the enclosed arc lamp was invented. In such a lamp the arc is produced as in the open arc between carbon electrodes. It is, however, enclosed in a nearly air-tight chamber of glassware known as the inner globe, to distinguish it from the much larger outer globe used on nearly all arc lamps. The air being excluded the electrodes are consumed slowly, their life averaging about 100 hours, or about ten times that of the open arc. However, more expensive electrodes must be used, since they must fit quite closely into a gas cap at the top of the inner globe, and yet be fed by the mechanism with perfect freedom. Forced carbons are used in enclosed arcs and moulded carbons on open arcs. Enough air must be introduced into the inner globe of such a lamp to consume all the carbon volatilized by the arc, in order that it shall not deposit on the interior of the inner globe and shut in the light, lowering the efficiency of the lamp.

(*d*) Later improvements in the production of light from an arc lamp consist in securing more light from the arc stream. This has been accomplished by impregnating the electrodes with some metallic salt. The light from an arc stream of pure carbon is purplish in color, but since it comprises such a small proportion of the total light from the lamp, its effect is scarcely noticeable except when colors are being matched. Salts of certain metals, such as calcium, strontium, barium, titanium, sodium, etc., give their own characteristic color to the light, raising its efficiency by luminescence. These salts tend to make the arc unsteady or flickering, necessitating the introduction of other compounds to steady the light. Arc lamps using impregnated electrodes are known as flame arcs. When magnitite is used for one of the electrodes, the lamp is called a magnetite or luminous arc, the latter being a trade name. Magnetite, containing iron, furnishes the conducting material in the arc stream. Most of the light is produced by a compound containing titanium, which is mixed with the magnetite. The electrode consists of a thin iron tube into which ground magnetite, titanium oxide, and chromite are packed. The magnetite melts, volatilizes, and carries with it the titanium. The chromite is used to absorb the fluid magnetite and steady the arc.

The electrodes in a flame arc lamp are consumed very rapidly. Even with long electrodes (14 to 18 inches), they do not last more than one night, or about 10 to 17 hours. The magnetite electrode, on the other hand, lasts from 85 to 200 hours, depending upon the current used. Since the electrodes contain considerable quantities of foreign impregnating materials which are not consumed in the arc, it is impossible to apply an ordinary inner globe to such a lamp. In fact, a draft tube or chimney is usually employed to carry away the products so that they are not deposited on the outer globe. It is obvious that such an opaque deposit would shut in most of the light after the lamp had operated a short time.

In the long burning flame arc an attempt has been made to partially enclose the arc. Such a lamp has a fairly close-fitting inner globe and a condensing chamber. The gases pass first from the arc to the cool condensing chamber, where they deposit the foreign material. They return along the sides of the inner globe by natural draft. Otherwise the opera-

tion is similar to that of the enclosed arc lamps. The electrodes have a life of about 70 hours with ordinary current densities.

There are two systems of electrical distribution, series and multiple. The series system is almost universal for street lighting. Either direct or alternating current may be used on either of these systems. Certain types of arc lamps will operate on either direct or alternating current, others on direct current only. In the direct current system, the current always flows in the same direction—i. e., from the positive terminal of the generator through the external circuit, and back to the negative terminal of the generator. In the alternating current system the direction of flow of current changes very rapidly, and the electrodes of a lamp must change in polarity at the same time as that of the circuit. In a 60-cycle alternating current circuit the polarity changes 120 times per second. It is obvious that the current must be zero at some instant during the change. Hence the conducting path must have a low enough resistance to allow the current to pass again easily. In order to produce sufficient conducting material for an alternating current arc, one or both of the electrodes is made hollow, and filled with a softer and more volatile substance in the form of a continuous core. These electrodes are slightly more expansive than those used in the direct current lamps.

For street lighting, lamps are usually operated in series—i. e., the same current passes from the station through all the lamps in one group or circuit and back to the station. Apparatus is provided at the station to keep the current constant for each circuit of lamps. The mechanism of the lamp regulates the arc length and holds the voltage across the arc constant. This mechanism must also be able to start the lamp at any time, or to cut it out of service without breaking the circuit, if, for any reason, the lamp is inoperative, as any break in the circuit will cut out all the lamps of that circuit.

The first machines for supplying electrical energy from central stations were for the production of direct current. These machines were nearly always made to supply power to incandescent lamps at a low potential, about 100 volts. They were unsuitable for operating more than two arc lamps in series. Accordingly, direct current arc light generators were devised. Many of the early types are still in use with very little change from the first design. When only direct current is available from a station, it is necessary to provide a separate machine for the arc lights, since there is no means of changing low voltage direct current to a higher voltage. These machines can not be used to assist the low voltage machines in times of emergency. They thus form an additional investment and source of expense to the station for repairs.

Upon the introduction of alternating current generators and systems of distribution, direct current was driven out of the field where power must be transmitted for any considerable distance, on account of the fact that alternating currents may be transformed from one voltage to another readily and with very little loss. With low voltage distribution, a large investment, and consequent high fixed charge, is required, due to the heavy copper conductors necessary for efficient transmission. Since the greater part of the load on most central stations is due to incandescent lamps operated on multiple circuits, it was found desirable to install apparatus of constant voltage for their supply. Alternating current arc lamps were readily devised, and the direct current arc light generators were replaced by regulators or by constant current transformers, thus reducing the cost of station equipment.

Alternating current arc lamps are not as efficient light producers as direct current arc lamps, but the combination of alternating current arc

lamps and regulators is more desirable than separate direct current arc light machines. Recently, rectifiers have been invented to convert constant alternating current into constant direct current, so that nearly any type of lamp may be operated with fair efficiency and continuity of service from an alternating current constant potential generator. This has led to increased activity in the perfection of direct current arc lamps for street lighting. Thus, to operate constant alternating current arc lamps from a central station supplying constant potential alternating current for multiple incandescent lighting, there will be required additional equipment of arc light transformers or regulators. To operate direct current arc lamps from such a station requires the same equipment as for alternating current lamps and the addition of a rectifier outfit for each group of lamps; or separate direct current arc light generators must be installed. Series incandescent lamps may be operated on either of these circuits.

A standard voltage of 110 volts has been adopted for use on multiple lighting circuits. Since arc lamps by their characteristics require considerably less voltage, some device must be used in series with the arc on multiple arc lamps to limit the current to the proper value. Any such device entails a considerable loss. In direct current lamps this loss is proportional to the differences between the line and arc voltage, multiplied by the current flowing. When the line voltage is a little greater than twice the arc voltage two arcs may be operated in series. This method is not satisfactory, since if one arc goes out it extinguishes the other in series with it, or some complicated mechanism must introduce a resistance capable of absorbing the same voltage as one arc lamp.

In an alternating current system, a device known as a reactance coil may be used to reduce the voltage, at the same time absorbing only a nominal amount of power, not over 10 per cent. of the lamp watts. Such a device, however, introduces other undesirable factors into the circuit.

The reason for using series instead of multiple lights is partly due to the less efficient lamps, and partly to the larger and much more expensive conductors required for the multiple system. The current for each group of lamps may be carried over a rather small size of conductor, without regard to the number of lamps in circuit, if they are all connected in series. A No. 8 Brown and Sharpe gauge wire would be of sufficient current carrying capacity. Some companies, however, use No. 6 or No. 4 on account of the greater mechanical strength when open wiring is used. If the same number of lamps were fed over a multiple circuit, several times the amount of money would have to be invested in copper, making a more expensive and less efficient installation.

The accurate photometric measurement of the intensity of light from an arc lamp is very difficult to make even with the facilities of the best laboratories. This is due to the unsteadiness of the light. Devices have been made for determining the mean spherical intensity of such lights at one setting. These devices are, however, very expensive, and are beyond the means of most central station laboratories. The distribution curves, as published by many different writers, are usually quite reliable. They are sufficiently accurate for calculating street illumination. Such curves are illustrated in the following pages. It must be remembered in these comparisons that most curves are taken in a laboratory where the lamp is kept in proper adjustment throughout the test, and the glassware carefully cleaned. The actual illumination received from such lights, when in continuous service, and with ordinary care in trimming, does not average over 80 per cent. of the laboratory values. This loss of light is due to dirt on the glassware, deposit on the inner globe of enclosed lamps,

and lack of adjustment of the mechanism due to wear, corrosion, etc. On the whole, illumination readings of actual installations are much more reliable, if made with sufficient care.

There is great need of a new standardization of the method of specifying street illumination in the United States. In 1907 the National Electric Lamp Association adopted a standard specification for street lights. Comparative tests of the illumination thrown upon the street, at distances of between 200 and 300 feet from the arc, were made upon the various street lights then in use. From these values a factor known as the "X" value of the lamp was computed. The X value shows the relation between the illumination from the lamp in question and that given by a standard 16 candle power incandescent lamp at 1/X of the distance. Thus, for example, an arc lamp, having an X value of 4, gives the same illumination as a 16 candle power incandescent lamp at one-fourth the distance, and a lamp having an X value of 5 gives the same illumination as the 16 candle power incandescent lamp at one-fifth the distance. Thus a lamp which has an X value of 5, at a distance of 250 feet, gives the same illumination as a 16 candle power incandescent lamp at a distance of 50 feet. With the advent of the demand for brighter illumination in this country, necessitating closer spacing of the lamps, this specification is no longer a measure of the value of the lamp. Other methods of specification used in different countries, or by different engineers, include horizontal illumination on a plane about four feet above the street surface, illumination on a vertical plane at a given point, and illumination on a plane normal to the rays of light from the lamp and at various distances.

As will be shown later, the illumination on the street surface depends not only upon the light at a certain angle, but upon the distribution of light about the arc at all angles, and upon the height and spacing of the lamps. The specification of the illumination should also include the distribution of light about the lamp for a given condition. The amount and character of the illumination required depend upon the character of the street surface and the use made of the street. Thus a lamp with a good X value may be suitable for lighting one street, but wholly unsuitable for another.

Street lighting in different parts of a city must serve various purposes. For utility and safety, the business streets require a different treatment from the residence streets and suburban districts. Parks and open places require a still different arrangement of lights. A good division of the city is the following:

A. Principal business streets;

B. Important cross streets and boulevards;

C. Residence streets;

D. Outlying districts.

In the principal business streets the illumination should be more or less brilliant. It should be as uniform as possible, and of sufficient intensity to enable one to read ordinary sized print—i. e., at least .25 to 1 foot candle. In many cities in Europe the inclined carbon flame arc is used for these streets. The lamps are suspended over the center of the street from tall ornamental poles on both sides, and at a height of from 40 to 50 feet. They are spaced from four to five times their height. These produce a very beautiful effect, and the street is rightly illuminated. With the reflection from buildings, the illumination averages about two foot candles. This lighting is also carried out for short distances into the cross streets. In this country the flame arc has not met with favor on account of the high operating cost for the short burning arc. With the advent of the more modern long burning flame arc, this objection cannot be made, since, in lighting from large units spaced comparatively near together, the number of the lights will be nearly inversely to the mean lower hemi-

spherical candle power. This will be more apparent later. The standard for such lighting has not yet been set in this country. There is now a strong tendency toward clusters of tungsten lights, or arc lights on ornamental poles, placed low on both sides of the street. It is claimed justly that the best lighted streets attract the crowds and hence merchants are insisting upon brighter and brighter illumination on their streets, even assisting the city in meeting the additional cost of maintenance.

The boulevards and cross streets require a much less brilliant illumination. The principal cross streets do not usually have shade trees, and may be lighted either by high intensity lamps suspended high or low intensity lamps more closely spaced and supported low. The general characteristics of the streets will indicate the type of lighting to be used. In such streets, heavy slow-moving traffic is usual. The boulevards, on the other hand, are usually shaded and require the lights to be suspended low unless the streets are very wide. For shaded streets, lights upon ornamental poles at the sides of the streets are preferable to those suspended over the center, on account of the character of the street. By this is meant that since such a street is used mostly for light vehicles, moving more or less rapidly, lights should not be hung so as to blind the drivers. The appearance of such a street is improved by side lighting, or lights suspended fairly high over the center of wide streets. Probably from .10 to .5 foot candle is a good figure to use.

Residence streets should have one light at each street crossing, for the safety of vehicles and pedestrians approaching these crossings, as collisions are more liable to occur at such points. These streets are usually rather narrow and densely shaded, thus requiring the lights to be supported not over 15 to 25 feet above the street surface. The maximum illumination should not be too high or the minimum too low. The general average of the illumination should, however, be low. The character and color of the surface have a marked effect upon the lighting of such streets. It is well known that a street with snow upon its surface appears much better lighted than the same one when the snow has disappeared. It is usual in dim illumination to see nearly all obstructions as dark objects against the lighter background of the lighted street. Such a contrast is more distinct if the background is lighter. A macadamized road or asphalt pavement needs much more illumination than one paved with light bricks. Lights will not give good illumination at the middle of blocks 400 feet long if the lights are 25 feet or less above the street. The illumination in the immediate neighborhood of most arc lights is also higher than necessary for this class of street. In crooked streets or where the surface is uneven or hilly, lights must be spaced more closely than at every street crossing. Residence street lighting is the particular field for the incandescent light. In choosing a light for this class of service, the economic limit comes in the ordinary spacing of poles on the street, and the lowest value of illumination allowable immediately below the light. A street having many small lights, hung low and spaced rather closely together, has long been associated with the narrow street of the poorer quarter with its dingy appearance. The brilliant effect and white light from the tungsten light has done much to dispel this prejudice.

In the outlying districts, either the tungsten light or an arc light having low operating cost may be used. It is seldom that a community can afford to have an arc light at each street intersection in such a district. Hence for protection and safety, the tungsten light may be used to good advantage. A difference here may also be made between streets connecting trade centers and cross

streets. The former may be treated as boulevards or as residence streets, according to the traffic conditions.

It is thus seen that no specific rules can be laid down in street lighting. Each case to be handled is more or less special. However, in choosing a general lighting scheme for any city, the central station furnishing the power must also be considered. It would, of course, not be feasible to specify a variety of lights, requiring varied generating apparatus. In any system the station apparatus should be interchangeable from one circuit to another for continuity of service and low first cost and maintenance. Thus, if direct current lamps are chosen, they should all have the same current consumption and this should also fit well with incandescent lamps on the market. On the other hand, small compensators may be supplied with each alternating lamp to adapt it to any alternating current circuit.

Wires in series circuits have a voltage upon them at the station, dangerous to personal safety. The circuit may become accidentally grounded at some point, either by contact with a telephone wire or the limb of a tree when wet. In such case, the full voltage may exist between the other wire and ground. Hence, for safety to persons, these wires should not be allowed too near the ground. They are usually required to be strung on the upper cross arm of the poles. If they are brought down to incandescent lamps, suspended too low or strung on low poles, serious accidents are liable to occur. To avoid this, especially low poles should not be used for series lighting. For such service, tungsten multiple 110 volt lamps may be used from special feeder circuits or series lights on ornamental posts fed from armored cables buried in the ground. This latter applies especially to park lighting.

PRODUCER GAS INVESTIGATIONS

UNITED STATES BUREAU OF MINES

IT is well known that the Bureau of Mines of the Department of the Interior has been engaged upon a very complete study of the commercial production of fuel gas, and the results of these investigations have been collected into a resumé, forming a special bulletin of the Bureau, from which we make some extracts as of value to both the engineer and the non-technical power user. The detailed work of the investigators is given at length in the report, and everyone interested in gas power should examine this Bulletin No. 13, by R. H. Fernald and C. H. Smith.

When the United States Geological Survey began operations at the coal-testing plant erected at the Louisiana Purchase Exposition at St. Louis, Mo., in 1904, it had already outlined a comprehensive plan for the systematic study of coals, lignites, and other mineral fuels with reference to their suitability for particular purposes and the methods by which they could be utilized most efficiently. Recognizing the need of information on the relative economy of producer gas as compared with steam for power purposes and the lack of comparable tests of American coals in the gas producer, the Geological Survey undertook investigations of the merits of different coals as producer fuel for the purpose of promoting efficiency in the utilization of the nation's fuel supplies. These investigations were carried on at St. Louis, Mo., and, later, at Norfolk, Va., and Pittsburg, Pa.

The act of Congress approved May 16, 1910, transferred the fuel-testing work being carried on by the Geological Survey to the Bureau of Mines. This bureau is conducting producer-gas tests at Pittsburg, Pa., and is publishing and distributing reports relating to all the fuel tests made by the Survey.

These investigations into the possibility of generating producer gas in a commercial way for power purposes from the various fuels of the country have been associated with steaming, briquetting, coking, and other tests, all of which supplemented an examination into the nature, extent, and distribution of the fuels. The tests have all been made with carefully selected representative samples and carload lots of materials procured specially for the purpose by experienced collectors.

The investigations promise to yield a particularly important result—the development of greater efficiency in the use of all fuels. This result is of specific importance in States remote from coal supplies; for example, in New England, where the rapid growth of various industries in the last few years has made the coal problem important. No coal is mined in that part of the country, the supply coming from Pennsylvania, West Virginia, and Virginia, and a little of it from Canada. Thus manufacturers in New England have to pay for transporting fuel from the coal fields and yet compete with manufacturers who have coal at their doors. This condition has led to the general discussion of the coal problem in the New England States and even to the appointment of committees of manufacturers to consider methods of relief.

The investigations made by the

United States Geological Survey and the Bureau of Mines indicate that marked economies can be gained by a general use of the gas producer in New England and, moreover, that these economies will be sufficient to overcome the handicap placed on the industries there by coal transportation charges. In 1902 the coal consumed to produce steam power for manufacturing purposes in the New England States cost approximately $50,000,000, and the annual fuel bill of these States now approximates $100,000,000. The development of this power through the more efficient method suggested by these investigations would mean a yearly saving of many millions of dollars.

Many States of the West that have no good coal are also greatly benefited by the investigations, which have shown the adaptability of the gas producer for the utilization of low-grade coal, lignite, peat, etc. As mined, these fuels are not suited for use in boiler furnaces and will not bear long transportation, but the gas producer makes them of potential value. Thus the gas producer is an agency of conservation. It helps to keep low-grade coals from being permanently lost by being left in the mines in such condition as to make their future recovery impossible. In States in which deposits of low-grade coal, lignite, and peat are found the present cost of power, as developed in steam plants with coal that has been shipped a considerable distance, can be materially reduced by placing producer plants at the mines or bogs, so as to utilize these cheap low-grade fuels without cost of shipment, by generating electric current which can easily be transmitted to desired points within a wide radius.

Producer-gas investigations, including a systematic examination of fuel values and the most economical methods of utilizing the coals and lignites of the United States, were undertaken at the coal-testing plant of the Geological Survey at the Louisiana Purchase Exposition at St. Louis in 1904. The results of the initial tests, showing that most American bituminous coals and lignites would make good producer fuel, were so encouraging that the investigations were continued as an essential part of the researches of the Survey in its examination of mineral fuels in the United States.

A preliminary report summing up the work of the producer-gas plant at the Louisiana Purchase Exposition was published in Bulletin 261, and a detailed description of the plant, the coals tested, and the methods of conducting tests and of computing results was given in Professional Paper 48, Part 3. Brief summaries of the more important results of the tests made at St. Louis from May 1 to December 31, 1905, appeared in Bulletin 290. The period from January 1, 1906, to February 8, 1907, was similarly covered by Bulletin 332. At the latter date the St. Louis fuel-testing plant began to be dismantled in consequence of the closing out of the affairs of the Louisiana Purchase Exposition, and the producer-gas, steaming, and briquet equipments were moved to Norfolk, Va. This city was selected as the site of operations because it was desirable to test coals suitable for naval use and because buildings and materials were offered by the Jamestown Exposition Company.

After the close of the Jamestown Exposition the principal station for testing fuels and structural materials and for carrying on investigations relating to mine accidents was established by the Survey at Pittsburg, Pa. In taking up the producer-gas investigations at this point it was deemed wise to make a special study of low-grade fuels. The producer plant used at St. Louis and Norfolk was returned to the manufacturers in accordance with arrangements that had been made with the companies supplying it and a different type of plant was installed.

These tests in the gas producer have shown that many fuels of such

low grade as to be practically valueless for steaming purposes, including slack coal, bone coal, and lignite, may be economically converted into producer gas and may thus generate sufficient power to render them of high commercial value.

Practically every shipment tested in the producers, including coals with ash as high as 44 per cent. and lignites and peats high in moisture, has been successfully converted into gas that has been used in operating gas engines. It is estimated that on an average each coal tested in the producer-gas plant developed two and one-half times the power that it would develop if used in the ordinary steam-boiler plant. Such relative efficiencies probably hold good for the average installation of moderate power capacity, but the ratio is smaller when large steam plants of the most modern type are compared. It was found that the low-grade lignite of North Dakota developed as much power when converted into producer gas as did the best West Virginia bituminous coals when utilized under the steam boiler. Thus, through these investigations, lignite beds underlying from 20,000,000 to 30,000,000 acres of public lands, supposed to be worth little, have been shown to possess a large value for power development. As a result the money value of this Government land has been increased to the extent of probably $300,000,000 or more.

Investigations into the waste of coal in mining have shown that it probably aggregates 250,000,000 to 300,000,000 tons yearly, of which at least one-half might be saved. It has been demonstrated that the low-grade coals, high in sulphur and ash, now left underground, can be used economically in the gas producer for the ultimate production of power, heat, and light, and should, therefore, be mined at the same time as the high-grade coal. Moreover, attention is now being called to the practicability of further reducing this waste through more efficient methods.

The investigations herein reviewed also show that the general use of gas producers for the development of power means the practical elimination of the smoke nuisance. This result is especially important in cities that are compelled to use bituminous coals. At present several factors are working together to reduce the amount of smoke discharged into the atmosphere. Among these are:

(*a*) The elimination of numerous small, inefficient, poorly manipulated, individual house-heating plants by the introduction of district or central heating stations.

(*b*) The increasing use of electric power in factories, office buildings, and for miscellaneous purposes, and the resulting reduction in the number of small steam-power plants.

(*c*) The economic advantages that are bringing about the rapid introduction of producer-gas plants.

(*d*) The centralization of large producer-gas installations at the mines with the distribution of energy over extensive areas, either in the form of electric current or as gas.

As stated above, on the average 1 ton of coal in the gas producer will develop as much energy as 2½ tons in the ordinary steam plant. The great saving in fuel thus obtained has led to the installation within the last decade of several hundred producer-gas power plants throughout the United States. In the smaller plants anthracite is largely used, but bituminous coal and lignite are used in the larger installations. These producer plants are practically smokeless during operation. When fires are first kindled, more or less smoke is discharged, but after this preliminary period no smoke issues from the plant until it becomes necessary to clean the producer and rekindle the fires. In certain types of installations operating under suitable conditions the fires need not be drawn for months and at some plants not for years. It is no exaggeration to state that such plants are absolutely smokeless. In plants of other types,

or under conditions that do not permit long periods of operation without shutting down, new fires are more frequently kindled, but even then it is rarely necessary to produce smoke oftener than once a week and then only for a short time.

As a smoke preventer, therefore, the gas producer is one of the most efficient devices on the market, and furthermore it reduces the fuel consumption, not 10 per cent. or 15 per cent., as claimed for the ordinary smoke-preventing device offered for use in steam plants, but 50 to 60 per cent. Even the smoke which issues during brief periods from a producer plant is not objectionably black like that which comes from so many stacks in every industrial center. Architecture, too, gains, for the introduction of these plants tends to eliminate unsightly chimneys and in this way also promotes economy as well as efficiency.

One of the objections that is commonly raised against the introduction of producer plants is that they do not offer any convenient method of factory or office heating. This undoubtedly has been true, but in the near future it will be possible to provide such heating with comparative ease and little expense from producer-gas plants. One or two recent installations offer notable examples of such heating.

The establishment of producer-gas plants at the mines and the distribution of electric energy or gas over large areas will also tend to eliminate smoke. Such central plants can deliver high-voltage current 250 miles away. The movement to install them is hastened by the rapid development in the use of electricity for manufacturing and power-plant purposes and in particular by the electrification of railroad terminals. When a large percentage of the small, isolated, smoke-producing power and heating plants and all steam locomotives have been removed from the larger cities, the atmosphere of these cities will be much clearer and heavy financial losses directly traceable to smoke will be eliminated.

The abundance of natural gas and the multiplicity of uses to which it has been applied have led to a much greater appreciation of the advantages of gaseous fuel, and have helped to emphasize the value of the gas producer. During the past few years there has been great development in the utilization of producer gas not only for power purposes and in the manufacture of iron and steel, but in other industries as well.

Among the uses to which producer-gas fuel has been put are annealing, japanning, enameling, soldering, brazing, galvanizing, drying, evaporating, tempering, casehardening, type casting, yarn singeing, heating moulds, wash kettles, ladles, stoves, baker's ovens, and cooking. It has also been used quite extensively in brick, lime, and cement kilns, and in various types of ore-roasting furnaces.

In using producer gas as a fuel one should remember that the heat value of the gas is low compared to that of the other gases used for similar purposes, with the exception of blast-furnace gas. Natural gas has an approximate average heat value of 1,000 B. t. u. per cubic foot; the heat value of artificial or ordinary city gas is about 650 B. t. u. per cubic foot; whereas the heat value of producer gas ranges from 100 to 275 B. t. u. per cubic foot, according to the method of production. This relatively low heat value must be taken into account when considering the method of application. In spite of its low heat value producer gas is usually cheaper for work requiring relatively large quantities of gas than any other fuel, with the possible exception of natural gas sold at a low price.

The introduction of producer-gas fuel for all types of service necessarily requires at the present time a certain amount of careful engineering promotion, due to the uncertainty that exists regarding its successful use in fields in which natural or artificial gas or even solid fuels have

been in vogue for years. In one extensive installation in which producer gas is distributed over a large area from one central plant, perfect confidence has been established in its reliability for continuous service and in the uniformity of the heat value of the gas. However, there seems to exist in the minds of the manufacturers who would like to utilize it some uncertainty regarding methods of application that will insure the uniform output of their product with the same guaranteed quality as their present output prepared with a gas of higher heat value. It has been necessary, therefore, to erect at the central plant different types of furnaces, ovens, forges, etc., and to make definite applications of producer gas to the various industries in order to demonstrate conclusively the ease with which this fuel can be applied to the various mechanical trades. Much of this pioneer work has now been accomplished and has resulted in the use of producer gas as a fuel in a large variety of mechanical operations.

In many possible applications of producer gas as a fuel there seems to be little if any gain over direct firing with coal. Opinions differ regarding this point, many claiming that there is always a considerable saving in favor of producer gas. The difference either way is probably small, but other considerations are frequently of such importance as to give producer gas a great advantage. Under conditions requiring uniformity of temperature for continued periods, or variations in temperature at positive intervals, the ease with which the supply of producer gas can be regulated insures results that would be entirely impossible with solid fuel. Producer gas may also be employed with comparative ease as a reducing agent.

Under the simple conditions required for boiler heating, it is questionable whether any advantage is to be obtained by the use of producer gas except, possibly, where low-grade fuels are burned. There are many fuels that can be utilized to advantage in the gas producer that cannot be employed in direct steam-boiler firing. An incidental advantage which may be important in urban communities is the reduction of smoke resulting from the use of the producer.

In large plants there may be considerable advantage in using producer gas in place of coal, due to the fact that the gas can be so easily piped from the producers to different parts of a plant. This advantage is particularly marked where it is inconvenient to distribute coal to several boiler installations, and may result in a considerable financial saving. Some writers on the subject are enthusiastic enough to believe that the manufacture of producer gas by large central plants at the mines, and the distribution of this gas through pipe systems over a broad area, will become general within the next few years.

In lime burning it is claimed that greater ecenomy is obtained with producer gas than with coal, and that the output of a plant is considerably increased. The heat produced by the gas is readily controlled, and it is claimed that the flames from burning gas are ideal for the process. Owing to the adsence of ash and clinker a much cleaner and purer product is produced, and the labor required is reported as considerably less than that demanded with solid fuel. Reduction in the repair bills is also claimed, as the life of the kilns is longer and the necessary repairs are less than when solid fuel is used.

Although producer gas has been satisfactorily used for ore roasting, the development in this direction has been slow, owing to the fact that there is a natural hesitancy about adopting new methods.

In forge work the substitution of producer gas for oil, city gas, and natural gas is developing, although special care is necessary regarding the methods of application. Producer

gas is economical and does away with the dirt and smoke so prevalent in forge work when coal is used.

The substitution of producer gas in place of coal for cement burning seems to offer an attractive field. Although this substitution has been made in only a few instances and has not become general, it is attracting the attention of manufacturers. It is claimed that excellent economy is obtained, that a high-grade, uniform clinker is produced, and that the ease of control, the simplicity of the equipment, and the low cost of the installation and up-keep make producer gas an ideal substitute for coal. In discussing this question cement manufacturers have expressed the opinion that the application of producer gas to clinker burning presents many of the advantages named, but at the same time they state that, as far as their information goes concerning installations of this process, there has been difficulty in getting as large an output as had previously been obtained with coal.

CAPACITY OF PRODUCERS

It is customary at the present time to designate the capacity of gas producers in terms of horse-power. As is the case with boilers, however, this usage is a misnomer, since there is no such thing as the horse-power of a producer. The expression strictly means the size of producer that will uniformly supply an engine of a given horse-power rating with gas over a considerable period of time; that is, a 250 horse-power gas producer means one that will supply sufficient gas to operate an engine rated at 250 brake horse-power for several consecutive hours under full load.

For metallurgical and furnace purposes in which no engine is employed there is no definite relation between horse-power and producer size. In general, then, a better method is to designate producers by the diameter of the fuel bed and the rate of burning the fuel per square foot of fuel-bed area.

This rate of fuel consumption is an uncertain factor and has led to much difficulty in designing and in rating producers. Early work in this country followed European practice almost entirely and thereby occasioned a great deal of trouble in properly rating the plants and brought about the ultimate failure of many of them. Under European conditions, in which fuels of a certain grade are specified, high rates of fuel consumption may be obtained. It is not impossible to obtain similar rates under corresponding circumstances in this country, but as these exceptional conditions seldom prevail, it has been found that in general the rate of fuel consumption per square foot of fuel-bed area does not average much over half the amount originally guaranteed by the early manufacturers. This fact has, of course, led to a decided modification in the design and proportions of many plants. Even today there is some tendency to overrate producers, especially those of the suction type. Such overrating is not only likely to make trouble in adjusting the purchase price of these plants, but usually results in serious operating difficulties, if the installation is worked at or near its capacity. It has been observed frequently that a given plant using anthracite of good quality will present no operating difficulties when working up to 50 or 75 per cent. of the rated capacity of the producer, but if the producer is forced to its full rating for any length of time clinkering and other troubles are encountered. These are often sufficiently serious to necessitate a reduction in load at a time when such a reduction is most inconvenient.

Certain types of fuel, such as the lignites of the United States, permit a high rate of fuel consumption, especially in producers of the downdraft type. Plants are in operation which are consuming more more than 40 pounds of lignite per square foot of fuel-bed area per hour, but the majority of producers do not gasify

ordinary fuels at any such rate. It is true that suction and pressure producers may be made to gasify comparatively large quantities of fuel per hour for relatively short periods, but in actual operation with ordinary grades of fuel it is doubtful if the consumption will exceed 15 to 16 pounds per square foot of fuel-bed area. The normal figure seems to be much nearer 10 pounds, although, of course, some variation should be allowed for the "workability of the fuel." Even 10 pounds may be a high figure in the case of fuels having a large percentage of ash or a sulphur content that tends to produce serious clinkering.

Of late considerable emphasis has been laid upon the rate of fuel consumption and the tendency to overrate producer plants for power purposes, and manufacturers of producers are giving these matters much consideration.

The depth of the fuel bed carried in the various plants seems to differ considerably. It is essential to have the fuel bed at all times deep enough to properly reduce the carbon dioxide to carbon monoxide. It is also important that the fuel bed be deep enough to prevent excessive heating and burning of the gas and the formation of large channels by the draft. The proper depth of the incandescent zone will of necessity vary materially with the character of the fuel, but in general will be from 2 to 4 feet.

When producer gas is used under boilers, and also in many metallurgical and other heating processes, impurities in the gas, as well as dust and ashes, are in no way detrimental to succesful operation. Under such conditions expensive equipment for gas cleaning is unnecessary, and the gas may be taken directly from the generator to the furnace in which it is to be burned. As a result the gas reaches the furnace at a high temperature, which aids in maintaining favorable combustion conditions and is also a factor in the high efficiency obtained. In gas as it comes from the generator there are usually a number of hydrocarbon compounds and tar vapors which condense upon cooling. These appear in the hot gas in such form as to be readily burned, and add materially to the total quantity of heat derived.

When, however, the gas is to be used in an engine, it is imperative that no tarry products be allowed to collect in the valves and passageways leading to the engine, and also that all grit and dust be kept from the inside of the engine cylinder in order to prevent damage by scouring. Under these conditions it is exceedingly important that the gas be properly cleaned. In addition, it is desirable to send the gas to the engine at a low temperature, as the cubic content of the engine cylinder is a fixed quantity and a much larger quantity of heat energy can be put into the given space if the gas is cold than if the gas is hot. It is desirable, then, after the gas leaves the generator and before it reaches the engine, to free the gas from all dust, soot, ash, and other similar material, to remove all tar vapors which upon condensation would cause trouble, and also to cool the gas to as low a temperature as is consistent with conditions. This process of removing the impurities is called scrubbing and is a simple operation. During this scrubbing process the gas is usually cooled to or a little below the temperature of the surrounding atmosphere. The cooling process also tends to dry the gas to a certain extent, although dry scrubbers are frequently installed for this purpose.

If charcoal, coke, or anthracite is the fuel used, the percentage of tar in the gas is small, and hence, with a proper scrubbing device, little or no tar is usually carried to the engine. Still, it is not always possible to remove all of the tar, and it then becomes necessary to see that the engine valves and passageways and the engine governor are properly cleaned at frequent intervals.

In the case of bituminous coal, lignite, peat, and other tarry fuels the scrubbing process alone is not sufficient to remove the tar, and it is essential that more effective means be employed.

The method of tar removal in vogue is by means of the mechanical tar extractor. The details of the various extractors differ somewhat, but the essential feature is a disk or fan rotating at high velocity, through which the gas with its tarry constituents passes, accompanied by a liberal supply of cold water. The water containing the tar and foreign matter is thrown by centrifugal action to the outer rim of the revolving disk or disks and passes to a water seal, from which the tar can be readily removed when desired. The principal objections to this method of procedure are:

(*a*) The removal of the tar involves a serious loss in the heat value of the gas produced per pound of fuel, as the tar represents a large percentage of the total heat value of the fuel.

(*b*) The tar is usually a nuisance about the plant, as it is a dirty, disagreeable substance to handle, cannot be turned into ordinary sewer systems, and seldom finds a ready market for commercial purposes.

The indications are that a much more general use is made of tar from producer plants in Europe than from those in this country. One method of using this material abroad is to mix it with ashes from the producer and then spread the mixture in the yards for walks, roads, etc. At one installation of 20,000 horse-power the tar, of which there is necessarily a large output, is sold for roofing, paving, and briquetting purposes, and a limited portion is sent to tar distilleries. At another plant visited a special equipment is installed for the proper handling and preparation of this material for commercial use. The tar water runs into a large vat or cistern, and the tar is separated to a reasonable extent as the mixture passes over a series of screens. The tar is then drawn off into a large tank in the bottom of which are exhaust steam pipes. By means of the hot pipes the tar is kept sufficiently warm to be pumped through a pipe line to tank cars on the nearby railroad. The tar as shipped often contains as high as 20 per cent. of water.

The average weight of water-free tar recovered in this installation is 90 pounds per ton of fuel burned. The tar is used as pitch for a binder for fuel briquets and in the manufacture of various medicines. The price received per ton of water-free tar is about $4.25, which amounts to a return of approximately 19 cents per ton of coal fired, not taking into account fixed charges and labor expenses of separating the tar, which, however, amount to little.

Owing to the reasons mentioned the mechanical extraction of tar is undesirable, and many attempts have been made to utilize the hydrocarbon compounds and tarry vapors directly in the process of gas making by passing them through an incandescent fuel bed and transforming them thus into permanent gases. This process has been undertaken in many different ways. One method which is in use to some extent abroad is that of distilling the tar vapors from the fresh fuel at the top of the producer and then passing the products of distillation through a passageway outside of the producer shell to the lower portion of the gas generator and there directing these vapors into the incandescent bed. Under these conditions it is probable that little of the tar is transformed into combustible gas, as the larger part is undoubtedly burned. Still, this method of tar disposal is helpful. A larger portion of the carbon in the fuel remains for gas formation, as a part of the combustion is maintained by burning the tar instead of the fuel itself. There are many varieties of this general method of utilizing the tar, but up to the present they have not proved of sufficient commercial

importance to attract general attention.

Installations of this character are found occasionally in Europe, but, as is true at practically all plants abroad, the fuels used are limited to those low in ash, low in tar (usually not over 7 per cent), and noncaking.

Another method much used in this country for transforming the tar vapors into permanent gases is by means of the down-draft type of producer, in which the vapors and gases distilled from the fresh fuel charged at the top of the producer are drawn down by suction through the incandescent fuel bed in the central and lower portion of the generator. The supposition is that these tarry vapors when subjected to the high temperature of the incandescent fuel bed in conjunction with a restricted air supply are converted into fixed gases, which become part of the gas mixture drawn out by the exhauster and sent to the gas holders. Under excellent operating conditions this change practically takes place, and, although a small portion of the tar vapors may be burned in passing into the incandescent bed, a clean gas free from tar and lampblack is developed. If the conditions are not quite so good and the temperature of the incandescent fuel bed is either too high or too low, difficulty is experienced in generating a clean gas. When the temperature is too low for the complete conversion of the hydrocarbon vapors a certain quantity of tar will pass through the system. This quantity is small and with most fuels is negligible, although experience has shown that it is practically impossible to absolutely eliminate the production of tar from a few varieties of bituminous coal especially high in tar-producing compounds.

Under certain operating conditions some of the carbon, owing to the restricted air supply, will be liberated in the form of fine, oily soot or lampblack. The formation of lampblack in down-draft plants is frequent, and satisfactory removal is somewhat difficult. No great harm results from this material in the majority of plants, although it is nearly as objectionable about a plant as tar. It is, of course, more easily disposed of and the quantity deposited is relatively small. As far as experience at the Survey's plants has shown there seems to be no injurious effect from lampblack in the engine cylinders, but the same may be said of tar. The difficulty with such material is not in the engine cylinders themselves, but in the passages, valve connections, governing attachments, and other mechanisms which may become clogged by these substances. The removal of soot or lampblack from the gas necessitates complete cleaning systems, as illustrated by the wet and dry scrubbers.

The opinions of those most familiar with the various processes of manufacturing producer gas from bituminous coal and other tarry fuels differ widely regarding the wisdom of attempting to transform the tarry compounds into permanent gases. The down-draft principle does not seem to be so popular in Europe as it is in this country. In spite of the many objections offered to the down-draft system it is interesting to note that over 50 per cent. of the total horse-power developed by producer-gas power plants in the United States is derived from down-draft installations, and that plants of this type represent a large percentage of the total number of installations operating upon bituminous coal and lignite. As indicated in the general discussion regarding the labor required in operating down-draft plants, the greatest drawback is not this question of converting the tar into permanent gases, for in this such plants are fairly successful, but the excessive labor involved in ash removal and in general cleaning, which is required under normal conditions about once a week.

LABOR REQUIRED IN OPERATING PRODUCER PLANTS

One of the great recommendations for the suction-producer plant, aside

from its natural fuel economy, is the small amount of labor and attention required when the fuel used is satisfactory, the producer-load factor is properly adjusted, and the operator understands the theory of the plant. It frequently happens in installations of moderate size, say from 25 to 100 horse-power, that the service required of the operator amounts to only 2 or 3 hours per working day, and the remainder of his time can be utilized in any way desired. If the fuel magazine is large, if the air and steam supply is automatically regulated with some degree of precision, and if the load upon the producer is not excessive, it is not difficult to meet the conditions mentioned above, but in installations in which these points are not taken into consideration, or in which incompetent operators are employed, the results are often exceedingly disappointing.

In general, pressure and down-draft plants are installed where relatively large units are desired. These units ordinarily run from 250 to several thousand horse-power, and hence it is practically imperative that one or more operators give their entire time to the producer-gas plant. The character of the employees required, the pay for their services, and the number of men necessary in a producer room will depend largely upon the general nature of the manufacturing plant. In installations in which a chief operating engineer of experience is required in the engine and generator room the labor for the producers may be reduced to a minimum. In one installation of 1,500 or more horse-power the producer labor amounts to one man per shift at $16 per week, with additional labor on Sundays to assist in cleaning the plant.

Considerable information relating to the details of such plants and the labor required in their operation is contained in the data published, obtained by a personal inspection of 69 producer-gas power installations in the United States.

In operating a suction plant care is taken to remove the ash and clinker at frequent intervals, which can usually be done without seriously interfering with the operation of the plant. As far as possible the clinker is kept near the grate and the ash is so removed as to keep the incandescent bed just above the grate from becoming clogged. This is essential in order to utilize as little of the power of the engine as possible in the production of the draft.

In the pressure system, unless grinding down of the ash is carefully looked after, there is a constant accumulation which may prove objectionable. Serious clinkering may take place in the fuel bed, but by proper manipulation the clinker may be so broken up that it will descend with the ash and be ground down into the ash pit. With these plants, often set up without a water seal, it is imperative that the regular operation be discontinued occasionally in order that the ash and clinker may be removed from the ash pit. It is possible to run these plants for two or three weeks without serious inconvenience with some types of coal low in ash, provided there is no overload demand on the producer. Generally, however, it is necessary to shut down once a week for the purpose of removing the ash and clinker. To overcome this objection in installations which do not shut down on Sunday the producer can readily be placed in a water seal, thus allowing the removal of ash and clinker at will without interrupting the continuous operation of the plant.

In the down-draft producer the ash and clinker accumulation takes place in the upper part of the coke bed and the lower part of the true fuel bed. The result is that there is no method of grinding down the ash or removing it during the process of operation. Hence the ash bed, and with it the fuel bed, rises higher and higher in the producer until the accumulation makes a shutdown imperative. Whenever possible, advantage is taken of the regular Sunday shut-

down for cleaning such plants, but in certain types of installations such shutdowns are not convenient, and it becomes necessary to carry a reserve unit which can be cut in when the unit in operation is cut out. Although this plan is severely criticised by those opposed to the down-draft system, in fairness it should be said that the plan is not essentially different from that regularly employed in the operation of boilers in steam-power plants.

When the ash content of the fuel is high, it frequently becomes necessary to cut out and clean a producer at shorter intervals than every seventh day. An extreme instance of this sort is a plant consisting of three units all under full operation. The fuel used is high in ash, and one unit has to be cleaned every third day, the plant running continuously 24 hours a day 7 days a week. In this way one unit is out of service for cleaning each day. It requires 6 men 8 hours to accomplish the thorough cleaning of the plant and the rebuilding of the fire; or, in other words, it is 8 hours from the time a unit is cut out from this system until it is again contributing gas of good quality. Although, at first glance, the labor involved seems excessive, the case is not extreme when one realizes that each unit is of 1,100 horse-power (3,300 horse-power for the total plant); that the plant is being operated to its full capacity all the time and beyond its rating a good part of the time; and that the total quantity of fuel used in the installation per 24-hour day is 80 or more tons. Computed on this basis, the labor required is practically the same as that for a corresponding steam plant, as far as the matter of cleaning and of handling the ashes is concerned.

It will be readily understood that the work of removing ash and clinker from gas producers is more or less expensive, dirty, and exacting. Although charging the fuel is a simple process and generally by no means laborious, yet considerable difficulty may be experienced in holding for long periods men that find any satisfaction in handling the cleaning processes now in vogue in the larger installations.

It seems important that simple and effective methods of cleaning be devised for such installations and that cleaning shall not interrupt the continuous and smooth operation of a plant. Although such methods may not be essential (and are not in use to-day) in the well-tried steam-power plants using coal as fuel and without reserve units, and although the matter of ease of cleaning may be carried too far for commercial success in the manufacture of producers, yet it does seem desirable that the present methods be materially changed and that the labor involved in removing clinker from the interior of producer shells be greatly reduced and simplified. The removal of ash can be made comparatively easy provided clinker production be reduced, but with a large proportion of the fuels available for use in the plants on the market to-day clinkering seems to be a serious matter, and interferes more than anything else, except the ignorance and stupidity of the operator, with the successful operation of the average plant.

So much difficulty has been experienced from channeling and clinkering in various producer plants that many attempts have been made to replace hand stoking by mechanical stoking. Various devices have been employed, one of which consists of a stirrer that projects into the fuel bed and is operated from the outside by shafting and gears. In another example the producer itself is divided into two or more transverse sections which are caused to rotate relatively to each other at a moderately slow speed. Other devices have also been tried with more or less success. It is claimed by the advocates of these devices that of necessity they produce more uniform conditions in the fuel bed than can be procured by hand stoking, because, being mechanical, they must operate at regular in-

tervals, are not subject to the whim or indifference of the operator, and because the ash is continually moved and ground down. This uniformity of conditions in the fuel bed naturally tends to produce a more uniform gas, and should result in a relatively large production of gas per square foot of fuel-bed area.

The opponents of mechanical stoking claim that since mechanical devices lack judgment the stoking is not done in a manner assuring the highest efficiency and most economical conditions in plants subjected to varying demands. It is also claimed that all such equipment adds materially to the care of a plant, that the apparatus is constantly undergoing repair and failing to respond to the requirements demanded, and that with some types of mechanical stokers the waste of fuel in the ashes is excessive.

It is true that to a certain extent both arguments are valid when different types of installations are taken into account and the various requirements imposed on plants are considered; it is also true that the character of the fuel has much to do with the success or failure of such devices.

One of the most common type of gas producer is the blast furnace. Of course, the blast furnace is not built primarily for gas production, and the gas is simply a by-product. The quantity of gas generated in the ordinary blast furnace is large, and its use for heating purposes and for power development in gas engines has increased rapidly during the past few years, especially since the introduction of the large gas engine.

The heat value of blast-furnace gas is low, averaging about 80 or 90 B. t. u. per cubic foot, but is an excellent gas for power purposes. Upon leaving the blast furnace the gas is exceedingly dirty, and before passing to the engine requires very thorough washing and cleaning, in order to prevent serious wear in the cylinders and the clogging of the engine passages. The cleaning equipment for such gas is necessarily large and expensive, but even with the high cost of cleaning it is economy to use this by-product, which otherwise would be wasted. Extensive installations of engines operating on blast-furnace gas are found all over Europe and also in the United States. Two of the most notable in this country are those at the Lackawanna Steel Company's plant at Buffalo, N. Y., and the Indiana Steel Company's plant at Gary, Ind. The former installation develops 40,000 horse-power by means of two-cycle gas engines in units of 1,000 and 2,000 horse-power, and the latter consists of 17 units of 2,000-kilowatt rating each and 16 blowing engines of about the same capacity. Six new units of 3,000 kilowatts each have recently been ordered.

Another gas that has been used more or less extensively and successfully abroad and in one or two installations in this country is that from the by-product coke-oven plant; therefore the by-product coke oven, in a sense, may be regarded as a gas producer. This method of gas generation has attracted considerable attention of late, and in the opinion of some will eventually cause extensive installations of large by-product coke-oven plants to be made. It is claimed that by this process the coke produced, which can be used for practically all domestic purposes, will pay costs and that all revenue derived from the sale of gas will be clear profit. Others believe that it will pay to erect such plants for the value of the gas alone, and that the coke will be a profit-making by-product.

One of the special advantages of gas, both as a fuel and for use in the gas engine, is the ease with which it may be piped to different portions of a plant. If the gas is properly cleaned and freed from tar, it should cause no trouble in the distributing lines. For local transmission the pressure may be very low (only an ounce or two), thus making the up-

keep of the pipe system small, as leaks can be stopped easily. No care is required in the way of insulation, as there is nothing which will condense in the pipes.

The situation is entirely different in the case of steam distribution. Here the pressures are high (100 to 150 pounds per square inch), the repair bill is often excessive, and leaks are a constant source of trouble. Insulation is also required, which adds greatly to the cost, and the methods of pipe laying are necessarily expensive. When steam lines are long and improperly insulated serious losses result from condensation. With steam the pressure in the lines must be high in order that the steam may enter the engine at or a little above the initial pressure required in the cylinder. With gas only enough pressure is required in the distributing lines to insure delivery, and in many cases the gas is below atmospheric pressure and is drawn into the engine by the suction stroke.

A large steam engine is usually erected close to the boilers in order to lessen the troubles from condensation, leakage, and the cost of installation. Owing to the ease of gas distribution, gas engines may readily be located at various portions of a plant.

The distribution of producer gas over extended areas is destined to become a considerable enterprise if the possibilities shown by such a plant as that described on page 68 are fully realized. For long-distance transmission of the gas the pressure in the mains is but a few pounds, being only 5 pounds in the plant referred to. This pressure is so low that the upkeep of the pipe line is a very small item.

In a great many producer installations little attention apparently has been paid to the proper location and arrangement of the operating rooms. The difficulties that are so noticeable in many steam installations are cropping out in producer-gas plants, especially if they are comparatively small. It is only recently that care in arranging the power end of a manufacturing industry has received proper economic consideration. Unfortunately there seems to be an idea that because economy in fuel utilization is claimed for producer-gas power plants, economy in every other direction must be practiced, even to the extent of sacrificing proper methods of installation and operation. This is an unfortunate attitude and is doing much to seriously interfere with the proper development of producer plants.

One of the primary requisites of producer installations is convenient access to all parts of the plant and perfect freedom in manipulation. Additional room should be allotted wherever necessary for the possible removal of any portion of the plant at any time, and the operating room should be sufficiently large to provide plenty of light and ventilation for the comfort of the operators. This is particularly important in plants of the pressure type, owing to the tendency of the gas to escape into the room. In any type of plant the removal of ash and clinker is always accompanied by more or less dirt and dust, gaseous fumes and heat, and unless proper care is exercised they may prove sufficiently obnoxious to cause not only serious inconvenience to the operator, but possibly his resignation. Satisfactory work can not be secured from operators who are required to labor in dark, dirty, cramped quarters.

Additional precaution should be taken to provide proper drainage. Not only is this important from the standpoint of cleanliness, but the wash water from the scrubber is likely at times to contain considerable sulphur and tarry matter, which may serve to clog the pipes and cause serious deterioration unless proper provisions for its disposition have been made.

AMERICAN POTASH DEPOSITS

THE WORK OF AMERICAN GOVERNMENT INVESTIGATORS

IN the course of the work of the United States Government to discover sufficient sources of potash within the limits of the country to place its agricultural industry beyond the necessity for any dependence upon imported supplies, some very interesting developments have appeared. Already some of the results of this work have been published in this magazine, and in addition to the alunite deposits of Utah and the leucite area of Wyoming other probable sources of potash of commercial importance are being reported.

The work of investigating the possible localities in which potash salts may be found is in charge of two Federal bureaus, one being the Bureau of Soils of the Department of Agriculture, and the other the Geological Survey of the Department of the Interior, and both have active field parties at work, so that there is every probability that American agriculturists will be relieved before long from the onerous dependence upon the Stassfurt deposits of Germany.

The principal difficulty, as has already been emphasized, is, not to find minerals containing potash, since these are both numerous and plentiful, but to discover some soluble forms of potash capable of use as a fertilizer, without involving recourse to chemical operations, which would render the cost too high to permit their practical use.

The German potash salts are practically ready for use as taken from the ground, and any American deposits which are to compete successfully should be able either to meet the cost of the imported product or create such competition as to prevent any arbitrary control of the market by a foreign monopoly.

From recent reports by the Government investigators, it seems as if their efforts are to be crowned with success, with the additional advantage that the United States will probably be provided with more than one source of potash of its own, and possibly be protected both against foreign and domestic monopoly.

A potash deposit of apparently great importance has been discovered at Borax or Searles Lake in the northwestern corner of San Bernardino County, California. This lake or playa is the last remaining pocket of a once much greater lake which has almost dried up, and its central depression contains a large body of crystalline salts known to consist of common salt and sulphate and carbonate of soda with smaller quantities of borax. This salt body is saturated with brine, and interested persons, stimulated by the governmental search for potash, recently secured an analysis of old sample material from this brine. The result being significant, the lake was visited jointly by representatives of the Geological Survey and of the Bureau of Soils, who took brine samples from six wells distributed over the salt flat. Analyses of these samples have been made by the co-operative laboratory at the Mackay School of Mines, at Reno, Nevada, and show an average of 6.78 per cent. of potassium oxide (K_2O) in solution. The average salinity of the brine is 43.82 grams of solids per 100 cubic centimeters. Comparison of the results indicates that the brines are nearly uniform throughout the flat. The probable importance

of the deposit is due to the occurrence of the potassium salts in soluble form in a natural saturated brine, and under climatic and other conditions especially favorable to its separation and recovery by solar evaporation. Existing data give reasonable assurance that the brine saturated salt body is at least 60 feet thick and covers an area of at least 11 square miles. Assuming the salt body to contain 25 per cent. by volume of the brine, the total amount of potassium oxide is estimated at over 4,000,000 short tons. This estimate is believed to be very conservative, and the available tonnage may well be expected to exceed 10,000,000 tons, which would supply the country, at the present rate of consumption of potash, for thirty years. At any rate, it appears that this locality constitutes a very important source of potash in probably readily available commercial form.

Methods of separating potash from brines are now under investigation by the Bureau of Soils.

Borax Lake, or Searles Lake, is one of the many playas or intermittently wet and dry lakes common throughout the arid regions of the West. It lies between the Argus and Slate ranges, in the Mohave Desert of southern California. Borax Lake was the original scene of the famous 20-mule team borax mine, the borax being hauled in great wagons drawn by 20 to 28 big mules to the Southern Pacific Railroad at Mohave, a distance of 80 miles. The lake or flat is about 10 miles long and 5 miles wide, and has received the drainage from the surrounding hills for many thousands of years, vast quantities of dissolved minerals being thus concentrated in it. The water has been evaporated under the intense heat of the long, hot seasons, but the salts have remained, so that for most of the year, in fact often throughout the year, the bed is a glistening plain of white salts, in attempting to cross which under a brazen sun men have lost their lives.

The mirage plays its strange tricks here, and at the dryest places the traveler can generally see what appears to be a broad expanse of water covering the bed a little way ahead—always a little distance off, until he approaches the shore of Borax Lake. Then, when he looks behind him, he sees the water apparently covering the ground over which he has just come. The lake occupies a valley made by faults—breaks and slips in the earth's crust—where a great area has been dropped down. Borings have been made through the mud and water underlying the lake to a depth of some hundreds of feet, the deepest borings made bringing up hot mud.

A reconnaissance of the general region was made by one of the geologists of the United States Geological Survey in 1900, and is described in the Survey's Bulletin 200, now out of print. Borax Lake itself, however, was not visited. The lake is also shown on a map in Water-Supply Paper 224 of the Survey, "Some Desert Watering Places in Southeastern California and Southwestern Nevada." Its nearest railroad is the Owenyo branch of the Southern Pacific, running from Mohave past Owens Lake. Borax Lake is situated about 20 miles from the station of Searles, on this railroad.

Many useful and curious minerals are found in the muds and other deposits of Borax Lake, including, of course, borax. Among them are gypsum, glauberite, carbonate and sulphate of soda, salt, thenardite, and hanskite. The last carries as much as 2.33 per cent. of potassium, equivalent to 4.44 per cent. of potassium chloride.

The salts are not evenly distributed over the surface of the lake. Borax was found plentifully over about 3 square miles, common salt is everywhere, and sodium carbonate and sodium sulphate are widely distributed. One boring is said to have passed through 28 feet of solid trona (hydrous carbonate of soda) of great purity. At other places there is 25 feet of solid mixed sulphate and carbonate of soda, with smaller quantities of other salts. Although the lake bed is dry

most of the time, a few inches under the outer crust there is always water—a bittern heavily impregnated with salts.

Several years ago an English company attempted to work the soda deposits on an extensive scale, but for some reason the work has not been pushed. This company sunk a number of wells, casing them through the soda deposits. It was found that a heavy stream of water could be pumped continuously without perceptibly lowering the water level. Potassium chloride and sulphate, the forms in which potash salts are most likely to be found in such deposits, are among the most soluble of salts and are likely to be much more generally diffused than salts less easily soluble. That the entire body of water and mud in the lake contains potash in a more or less uniform degree is indicated by the results thus far attained. However, there are modifying agencies, such as springs and streams, that bring in fresh water, for the movement of water through the lake will be slow owing to the presence of the sand and salts that fill the basin.

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Established 1891

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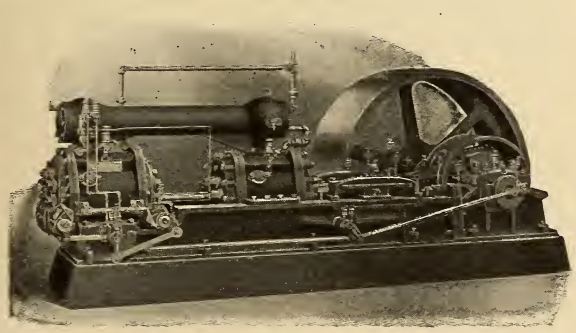

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Advertising Briefs

Based on happenings in the Day's Work—No. 16.

Talks by the other fellows

Last month we quoted from letters received, firms who expressed their satisfaction with advertising in Cassier's Magazine.

The following from a letter received from Mr. Fayette J. Clute, Editor, Camera Craft, San Francisco, California, explains one of the reasons for their satisfaction.

"For years I have kept my issues of your excellent 'Cassier's Magazine.' As a publisher myself, I wish to compliment you on the beauty of your magazine, particularly the advertisements. These last are about the best appearing in any trade publication that comes to my desk, not excepting two or three devoted to advertising and supposedly showing the best examples of magazine advertising composition."

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It is generally believed that a true appreciation of the work of a man who has been actively engaged before the public can be best gauged after sufficient time has elapsed to permit the superficial qualities to become eliminated and to allow the valuable characteristics to be fairly and fully considered.

This is especially true of such a man as Zerah Colburn, and it is believed that the reproduction of a somewhat rare portrait of this remarkable man and some mention of his work will be acceptable.

Zerah Colburn, the nephew of the famous mathematician of the same name, was born at Saratoga, N. Y., in 1832. His early opportunities were few and his education that afforded by the ordinary country school, but his eager taste for mechanical matters led him to leave the farm and obtain work on the Concord Railroad, while his desire to write appeared in the publication of a book on the locomotive engine when he was but eighteen years of age. He obtained shop experience at the Tredegar Iron Works, at Richmond, Va., and by 1853 he was in New York engaged in technical journalism as editor of the *American Railroad Journal* and as founder of the *American Railroad Advocate*.

From 1853 to 1857 he was engaged in various enterprises in connection with Horatio Ames, and with the New Jersey Locomotive Works, at Paterson, N. J. He had sold the *American Railroad Advocate* to Alexander L. Holley in 1853, and in 1857 both Colburn and Holley went to Europe upon a commission from a number of American capitalists, to examine and report upon European railways. The result was the remarkable volume entitled "The Permanent Way and Coal-Burning Locomotives of European Railways," which, it is generally understood, was written by Colburn, although it bears the names of both Colburn and Holley.

Colburn returned to America on the first voyage of the *Great Eastern*, in 1860, and started the *Engineer*, in New York, but at the outbreak of the Civil War he went again to England and entered the editorial staff of *The Engineer*, a connection which was severed in 1864. In 1866 he founded the journal *Engineering*, which he developed to a high standard, and from which he retired in 1869, returning to America in 1870, where he died by his own hand on April 26, 1870.

Zerah Colburn was a member of the Institution of Civil Engineers, and of the Institution of Mechanical Engineers, and a member and president of the Society of Engineers, and contributor of many papers.

ZERAH COLBURN

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XLII SEPTEMBER, 1912 No. 3

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OVERHEAD TRAVELING CRANES

By Joseph Horner

THE growth of the overhead traveling type of crane of late years has been phenomenal. Overhead travelers were common enough forty or fifty years ago, but the crude designs of that period have, with few exceptions, nearly disappeared before the improved forms of the present. This is due to the advent of electricity as a cheap and mobile rival to the older power agencies. At the present period it is difficult to forecast the directions in which further improvements can possibly be effected in this highly useful and popular form of lifting machine. This seems, therefore, a fitting opportunity to review the work which has been accomplished, and the present status of the overhead traveler, with the methods adopted in its design and manufacture.

Those who are not familiar with the intricacies and variations which occur in crane work may hesitate about accepting the statement that the overhead traveling crane represents one of the very broad designs which is varied in details almost more than any other kind of crane. One principal reason for this variation lies in the range of capacity of these cranes, which may be anything between 1 ton and 150 tons, and that of its span, say from 20 feet to 90 feet or 100 feet. The hoisting machine, which, perhaps, runs it most closely in this respect, is the type variously classed under goliaths and bridge cranes. These are cousin german to the travelers having crabs or trolleys. The difference is that the bridge girders travel on legs instead of along fixed rails. The designs of electric travelers are so far cut and dried that they are controlled largely and mainly by their power and capacity, and by the character of the duty which a traveler has to perform. A light crane is not by any means a replica of a heavy one. The two have scarcely anything in common beyond the capacity to travel down a gantry, and the movements of traverse and hoisting. All the separate details are distinct, and worked out in very different ways. Special industries require special cranes in which the standard designs are modified in various ways. Among these industries are the steel making, including furnace charging, and ingot and mould pouring. In these cranes the driver has to be protected in his cage from the intense heat of the metal.

The study of these cranes is naturally divisible under two sections, the structural work of framings and the operating mechanisms or machinery. The stresses due to the latter have to be resisted by the former, and these

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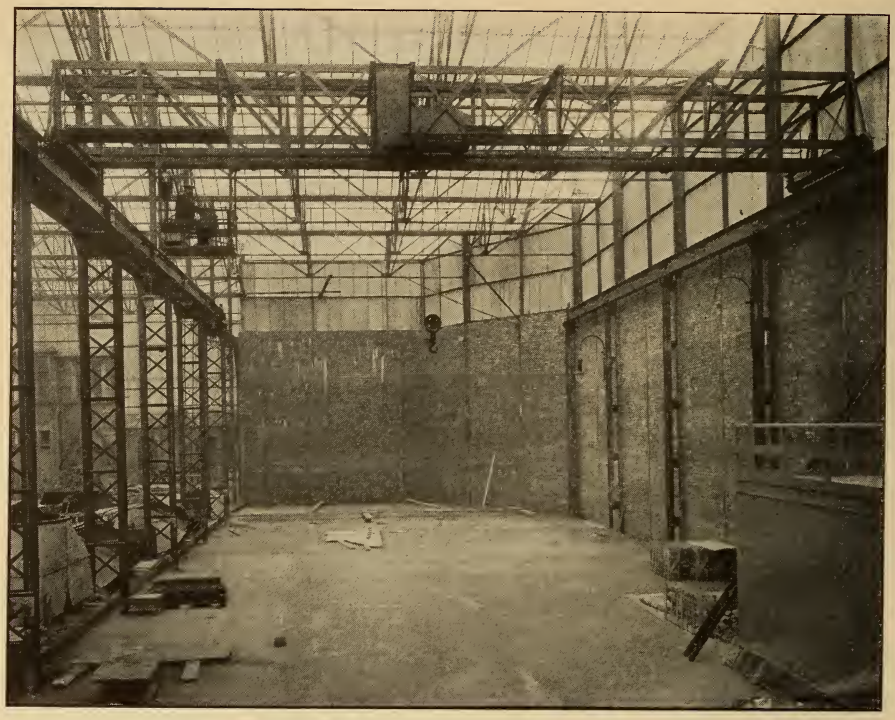
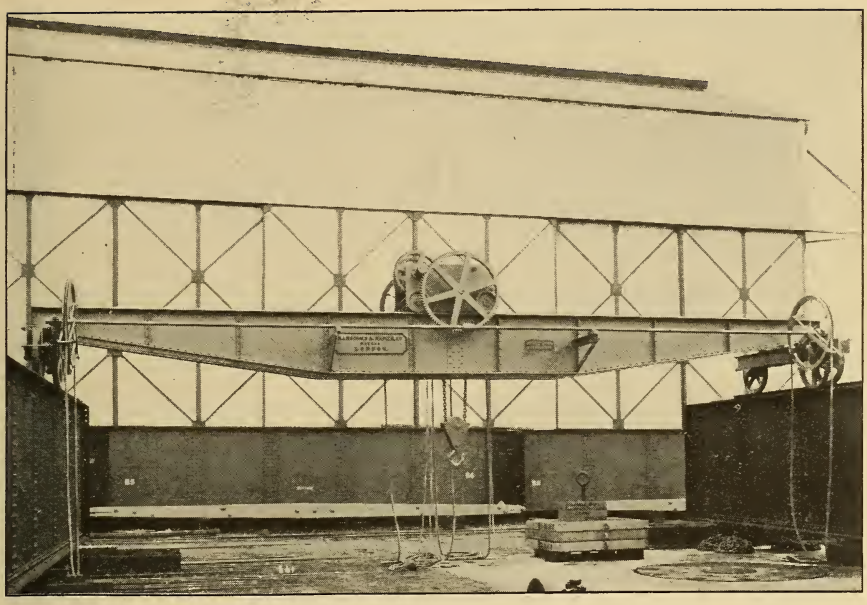


ELECTRIC OVERHEAD CRANE OF 5 TONS CAPACITY, 50.2 SPAN. GEORGE RUSSELL & CO., LTD., MOTHERWELL, N. B.

stresses are somewhat complicated. The dead loads due to hoisting are the simplest and most readily calculable. But the live loads due to travel and traverse cause strains which tend to pull a weak structure to pieces, and these are not readily estimated. It is a case of a bridge subject to a moving load, but one in which the bridge is also traveling bodily. In a weak structure or in one that is badly built, even though the design is structurally strong, there will be lateral racking thrusts on the gantry girders, and cross-working between the end carriages and main girders. If the loads imposed were always uniform and regular, the task of the crane designer would not be so difficult, but they are often of the nature of sudden surges and shocks, rapid accelerations and stoppages, that are difficult or impossible to put into formulas.

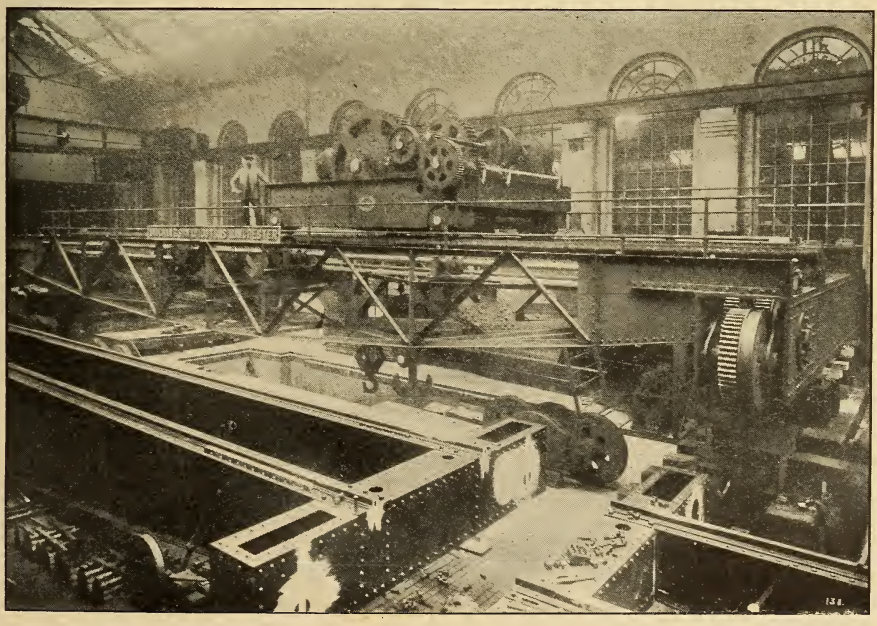
The structural work of the overhead traveling crane comprises the bridge or traveling girders, the end girders or cradles suitably mounted on flanged wheels, the crab, or the trolley (the first being by far the most common, the others, the simpler, being occasionally adopted) traversing along the bridge girders, and lifting and carrying the load. With the rapid movements now required the problem of combining strength with lightness has to be met less by massing of material as in the old practices, than by judicious distribution of the minimum of material. Let us now take the traveling crane to pieces and consider these elements in detail, with the modifications which they receive for different capacities and services. The illustrations represent every aspect discussed without the necessity for special reference.

The main girders are subject to two kinds of stresses, those due to the load acting vertically and those which come on it laterally when the traveling motion is started and stopped. The maximum dead vertical load is im-

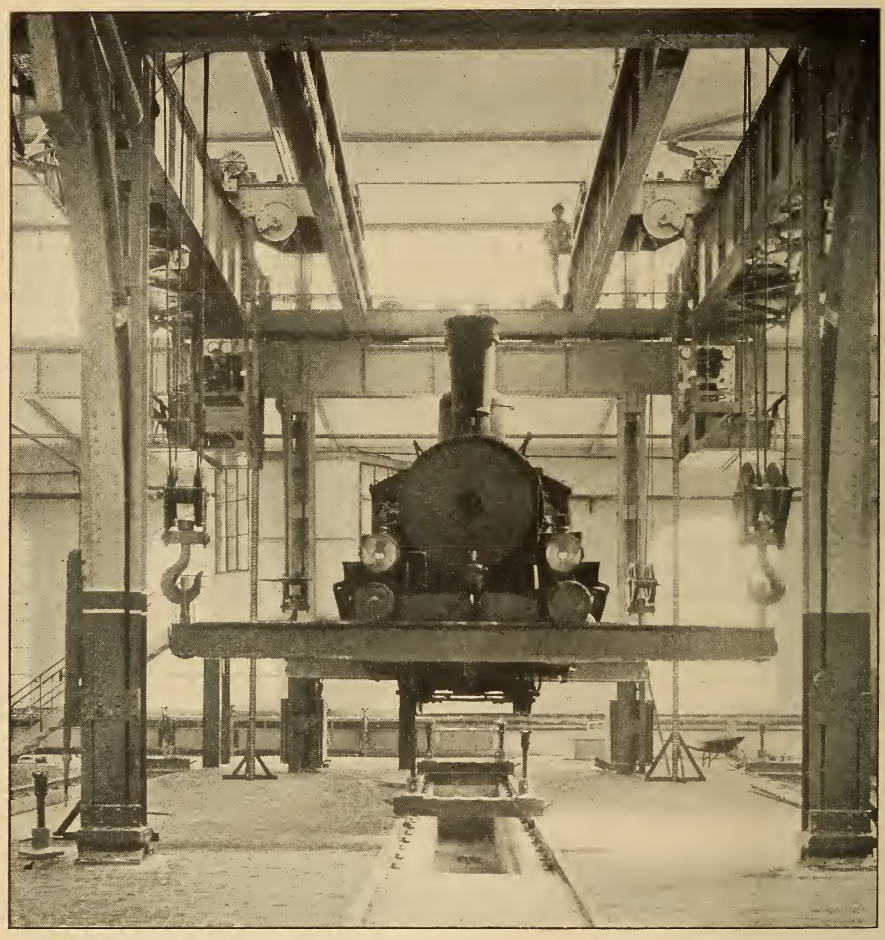


HAND TRAVELER WORKED FROM BELOW. RANSOMES & RAPIER, LTD., LONDON AND IPSWICH

posed on the girders when the crab is fully loaded and situated centrally, to which one half the load of the girders themselves must be added. A lateral stress comes on them when the crane fully loaded is started or stopped. This can only be estimated as a percentage proportion of the moving mass based on experiments which have been made, and it must be re-



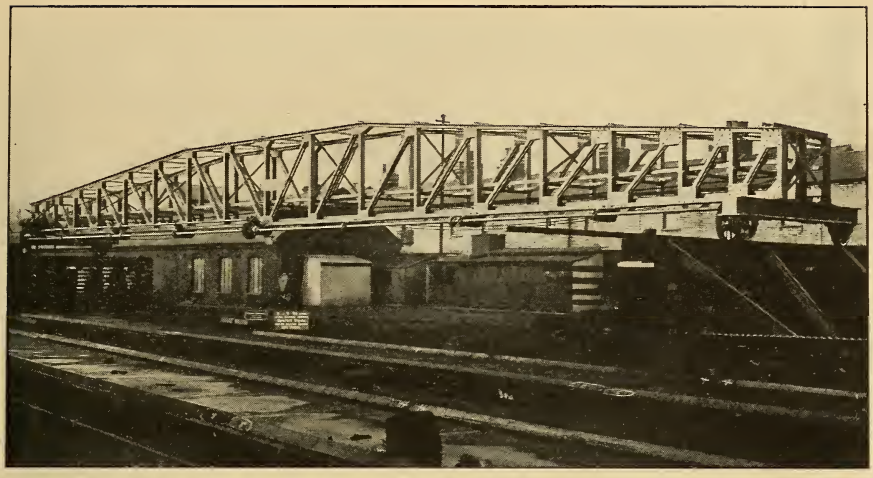
CRANE OF 100 TONS CAPACITY IN ERECTING SHOP OF VAUGHAN & SON, LTD., MANCHESTER



TWO OF FOUR 40-TON LOCOMOTIVE LIFTING CRANES. ZOBEL, NEUBERT & CO., SCHMALKALDEN
(T. & E. WANNBACHER, AGENTS, LONDON)

sisted by giving sufficient breadth to the flanges; to the top flanges when the crab runs on them, and tends to overturn the girders, or divided between bottom and top flanges if the crab runs on the bottom ones. But over and above the question of mere strength there must be ample rigidity in all elements, connections, and fastenings.

In the bridge girders the choice lies between the use of rolled joists, solid-plated web girders, single- or double-webbed, and lattice-braced girders, or a combination of plated and lattice girders, either being parallel, or fish-bellied, or only approximating to cambered outlines. Trussed timber beams have been often used for hand travelers, but are seldom made now, rolled steel joists (which may be trussed if thought desirable) being preferred. Rolled joists are often used up to loads of 20 tons, and to spans as great as 50 feet. Usually two girders are employed, with the crab or the trolley rails disposed on the top edges. In another type a trolley is suspended from a single girder, its wheels running along the inner faces of the lower flange of the joist. These are only made for light loads, not exceeding, say, four or five tons. Neither of these types is made as a rule for wholly electric driving. If an electric motor is fitted it is for hoisting only,



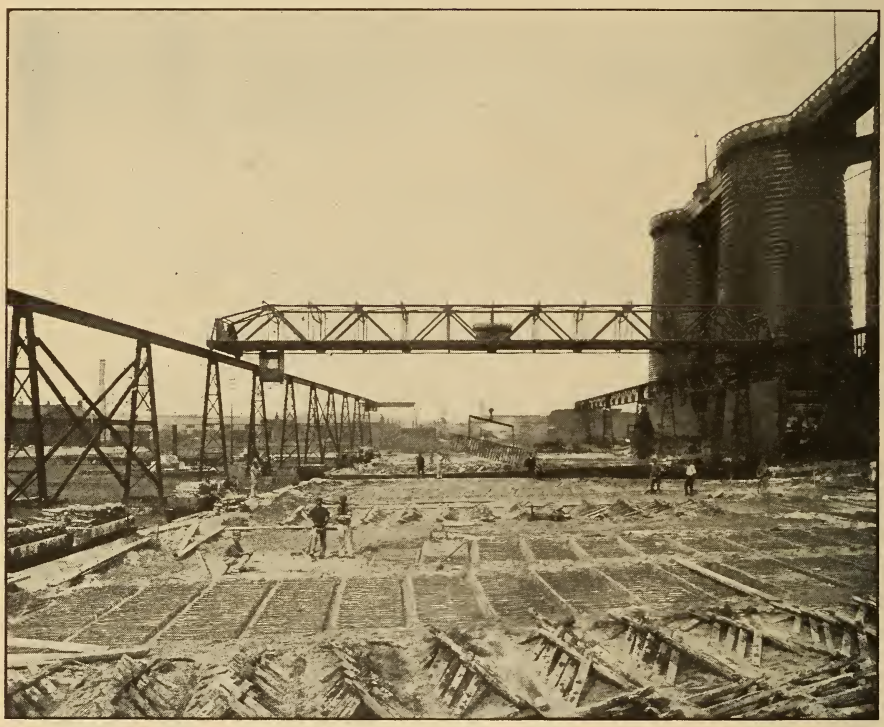
SINGLE-MOTOR ELECTRIC TRAVELING CRANE OF 5 TONS CAPACITY, 100 FEET SPAN, LIFT 22 FEET
RANSOMES & RAPIER, LTD., LONDON AND IPSWICH

leaving the traversing and traveling to be done by hand, with dependent chains. Often, too, the lifting is accomplished in the same way. The designs are old, and the difference between the old and the new is chiefly that of the motor fitting for hoisting. These rolled steel joists are convenient, suitable, and cheap forms of girders, and are, therefore, adopted extensively, but only for moderate loads and spans. For higher duties the built-up girders are necessary.

At one time large bridge girders

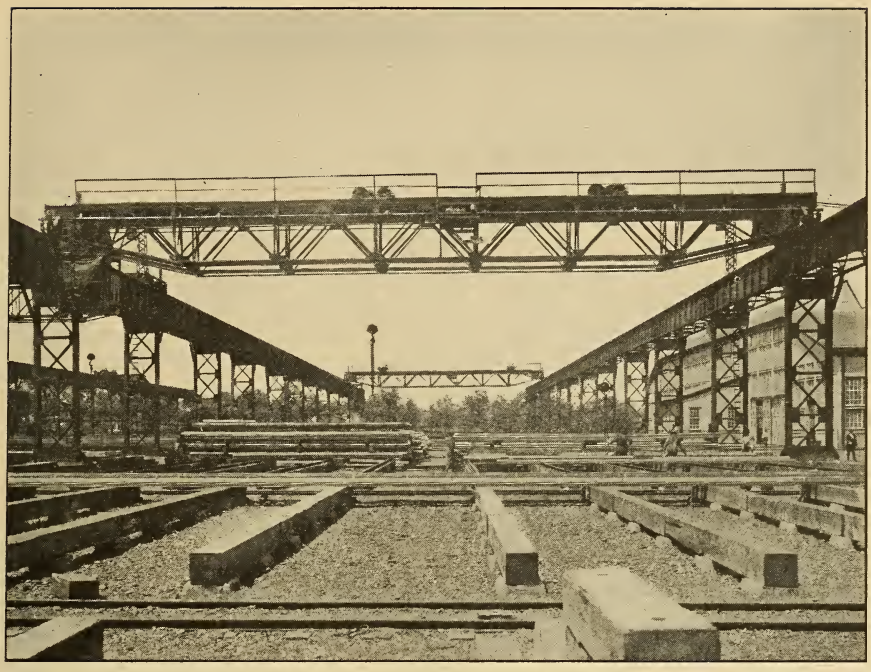
ELECTRIC TRAVELING CRANE FOR BUCKET AND LIFTING MAGNET. ZOBEL, NEUBERT & CO.,
SCHMALKALDEN. (T. & E. WANNBACHER, AGENTS)

were nearly always single-webbed, solid-plated wrought iron structures. To reduce weight the webs were made thin 5/16-inch to 3/8-inch, and strengthened against buckling by vertical stiffeners of T section. The objections to these on the score of weight and inertia arose when high speeds of travel came in, first on the advent of the cotton rope drive, and afterwards intensified by the coming shop, the details being repetitive. Speaking generally, plated girders are quite suitable for cranes of moderate spans, loads, and speeds, but for the contrary conditions the lattice form should have preference. Solid-webbed girders are generally more easily built than lattice-braced ones, and calculations of stresses are somewhat simplified. But the gain is not great, for the webs are very liable to buckle unless

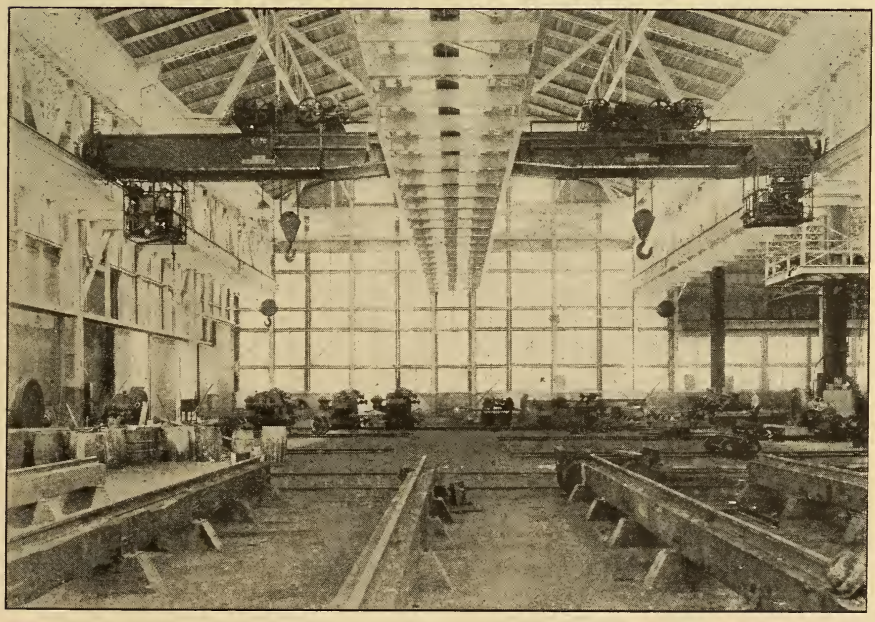


ELECTRIC OVERHEAD TRAVELING CRANE OF 10 TONS CAPACITY, BUILT FOR JOHNSON & PHILLIPS, CHARLTON, KENT. BABCOCK & WILCOX, LTD., LONDON AND RENFREW

of the electric drive, and again with the growth of very long workshops. The solid-plated girder was usually made of fish-bellied or cambered form in order to cut down unnecessary weight, and the same form is often retained in the lattice-braced girders, But the reason for adopting that shape does not exist in the same force when light lattice bracing is adopted, and, therefore, many girders are built parallel throughout, which somewhat simplifies the work of the plating heavy stiffeners are riveted down them. The thickness of the web cannot be materially increased because of the serious addition to dead weight and cost entailed. But there is an element of rigidity in a well-designed and suitably stiffened solid-plated girder which appeals to many. Greater care must be exercised in designing and making a lattice-braced girder to insure that the tension and compression bars shall be suitably proportioned to their loads, and the riveting must also

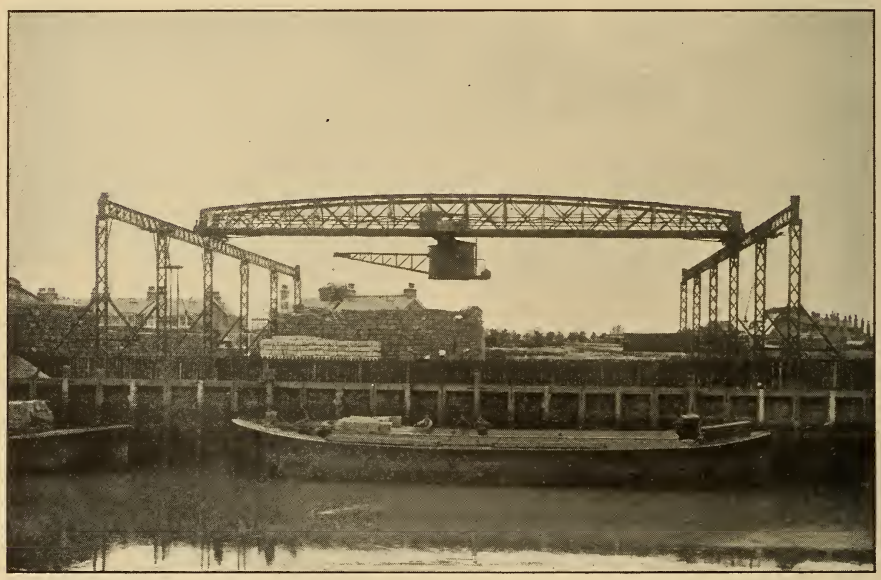


TWO 10-TON TRAVELING CRANES OF 90 FEET SPAN AT THE RECEIVING YARDS AT GARY, IND. THE CLEVELAND CRANE & ENGINEERING COMPANY, WICKLIFFE, OHIO



TWO 40-TON SHOP CRANES OF 34 FEET SPAN AT THE AMERICAN BRIDGE COMPANY, GARY, IND. THE CLEVELAND CRANE & ENGINEERING COMPANY, WICKLIFFE, OHIO

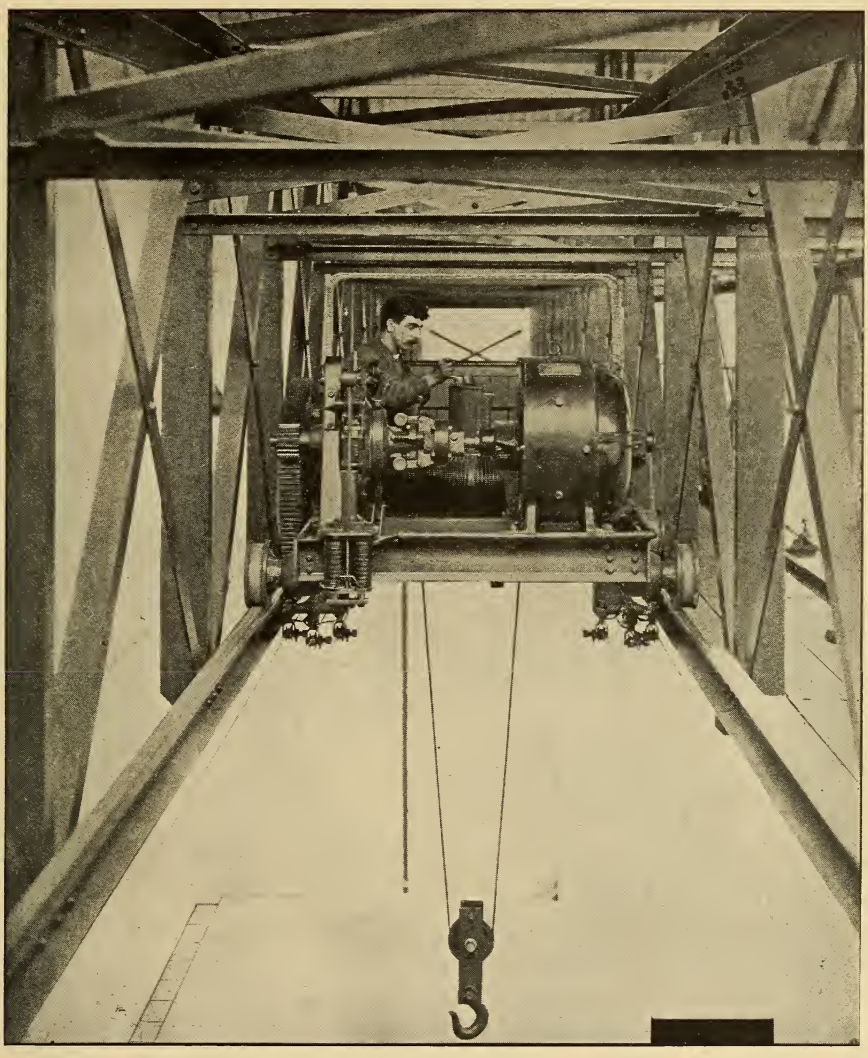
be done properly if they are not to work loose, or shear. The box girder would be more desirable still but for its great weight. A compromise is sometimes made—a solid-webbed girder, and a lattice-braced girder being combined. The two are situated several feet apart, at the distance of the width of the gangway or platform, and are connected with light lattice-bracing. Sometimes the platform itself is made stiff enough to afford lateral stability to the main girders. The box girder is sometimes adopted



FOUR-MOTOR OVERHEAD TRAVELING CRANE OF 1½ TONS CAPACITY, SPAN 110 FEET, FITTED WITH UNDER-HUNG JIB, FOR HANDLING PAPER PULP AT THE DARTFORD MILLS OF THE DAILY TELEGRAPH. ROYCE, LTD., MANCHESTER

in the heavier cranes, but a better form is the double-lattice girder. In this, four lattice girders are arranged side by side, connected in pairs. Lateral stiffening is then afforded by platforms, which, lying horizontally on the exterior of the outer girders, are effective in taking horizontal stresses. Examples of these are seen in some of the Ransomes & Rapier cranes. Lattice-braced girders can be constructed for the heaviest as well as the lightest cranes. What is suitable for a railway bridge is good enough for a crane. It is only a question of suitable proportioning. Bars and angles are suitable for light girders; bars and channels and joist sections for heavy ones, the angles and channels, or joists being compression members.

With regard to the longitudinal outlines of the traveling girders of the overhead cranes, there are good reasons for the variations which occur in these. They are parallel, or cambered, and the camber is either above or below. The crab travels on the top, or on the bottom flanges. Each has its own advantages under special conditions. Parallel girders are generally adopted for travelers handling light loads and for the shorter spans. They are easily and cheaply constructed, and as the stresses to which they are subject are not usually severe a strong case for camber does not exist. Though a good many heavy cranes have been made thus it does not strike one as good practice, because metal is not distributed to the best advantage. Cambered girders are most favoured for heavy loads and long spans because they approximate



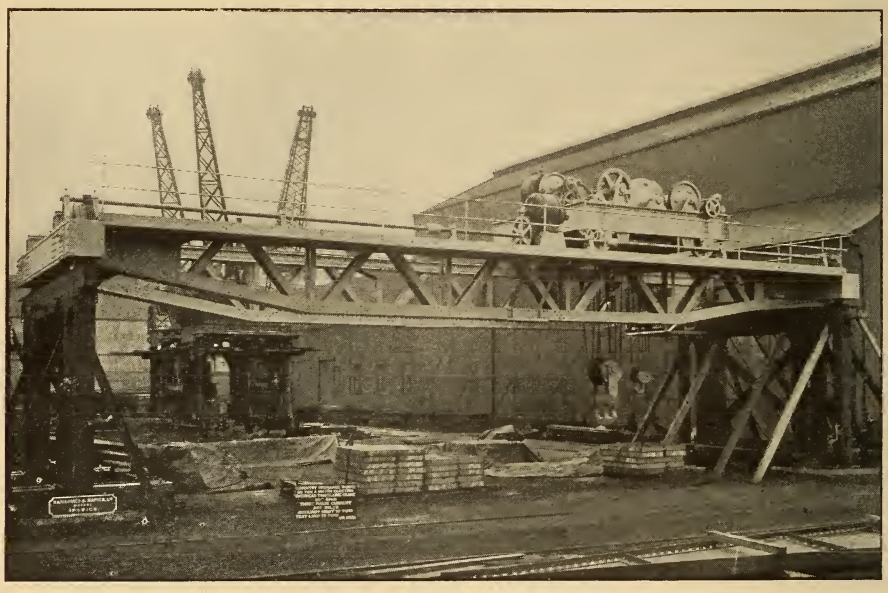
END VIEW OF CRAB OF 1½-TON, THREE-MOTOR CRANE, RUNNING ON THE BOTTOM FLANGES OF LATTICE GIRDERS, THE TOPS OF THE GIRDERS BEING CONNECTED WITH CROSS BRACING.
ROYCE, LTD., MANCHESTER

to the double parabolic form, which is the one best correlated to the loads and the strains. The camber may be all disposed below, or all above, the first when the crab travels along the top flanges, the second when it runs along the bottom flanges. There is a modified form of camber in which the curve is avoided. The top and bottom flanges are parallel over a considerable portion of the length. Then, measured equidistantly from the centre, the flanges are sloped away to the ends. The only advantage gained is that the construction is slightly simplified, bending of angles being avoided, and the many variations in the lengths of the bracings reduced.

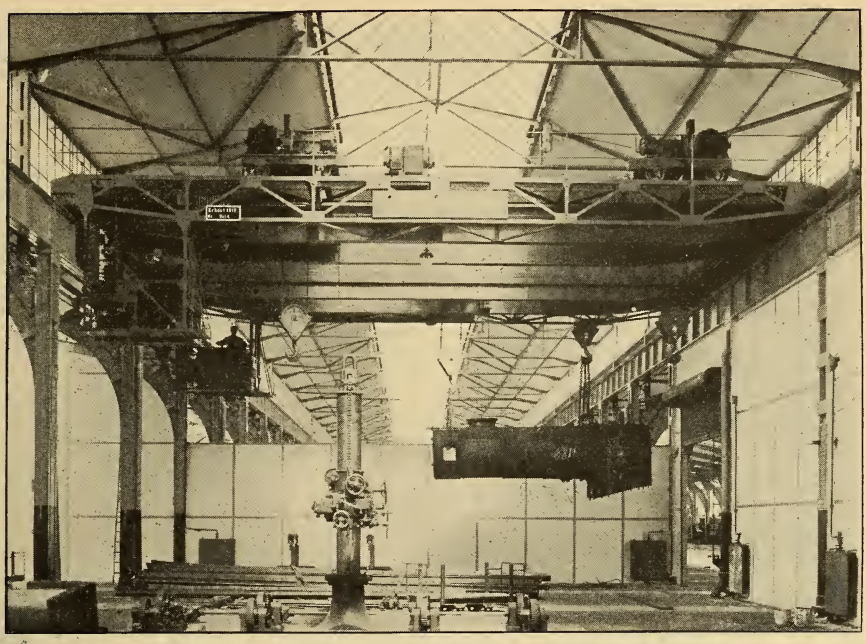
The location of the crab, whether on the top or the bottom flanges, is important. By far the more usual position is on the top, in which case the girders cannot be tied together anywhere except at the ends. But if

placed on the bottom the top flanges can be lattice-braced throughout. A minor advantage is that the center of gravity being lower down, this is more favourable for starting and stopping when high speeds of travel are adopted. But the question of the location of the crab is also one of head room. If this is very limited, room can be economized by placing the crab within the girders, running it on the bottom flanges instead of on the top. The amount of head room available must often influence the general design of a traveling crane. If this room is ample the designer has a free hand. But if, as often happens, it is limited then the crane must be built to suit. This alone is often sufficient to explain the variations which one sees in traveler designs. It may impose upon the crane maker the placing the crab within the girders running on the bottom flanges. Or a jenny may have to be employed instead of a crab, though that is not a desirable arrangement if it can be avoided. The more powerful the crane the greater is the height of head room required, because of the larger diameters of the rope drums, of the gears, and of the main frames which carry them, and of the depths of the main girders.

By far the larger number of overhead travelers work in shops under cover. For outdoor service protection from the weather has to be afforded to the machinery of the crab and to that in the operator's cage. This is a corrugated sheet iron house, such as is used on other forms of outdoor cranes. In cases of this kind preference is frequently given to the design in which the crab runs on rails on the bottom flanges of the girders. This is better than the usual design, because these travelers, occupied in long yards for stocking and handling steel plates and sections, or working over pig beds, travel and traverse at very high speeds, exceeding those usual in shop travelers, and the form is well adapted to resist inertia stresses and risk of overturning. The weight is mostly below instead of above, and the light lattice-braced girders are united above by means of lattice-braced transverse girders, and

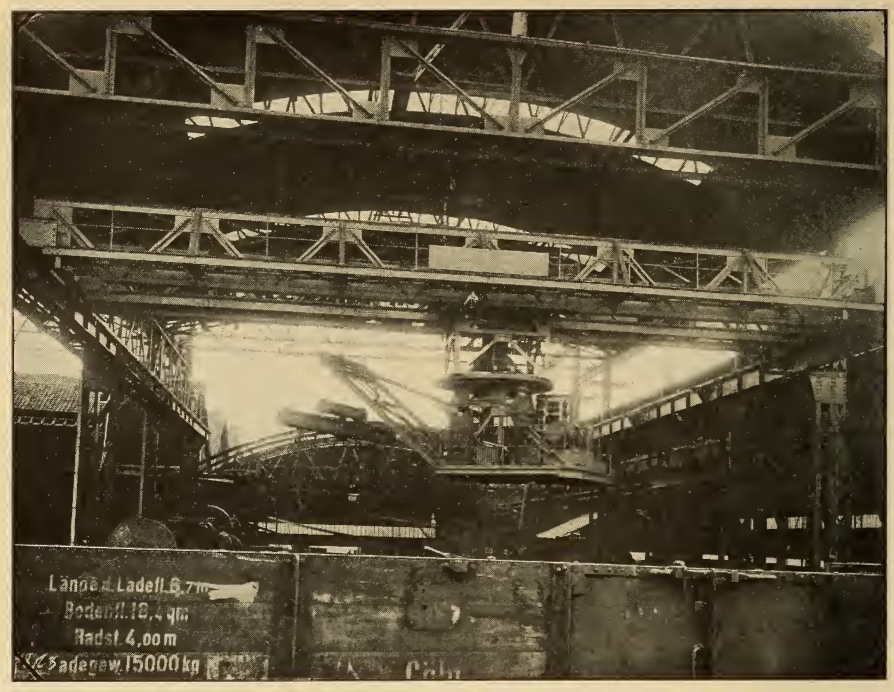


FOUR-MOTOR ELECTRIC TRAVELING CRANE OF 60 TONS CAPACITY WITH 10-TON AUXILIARY HOIST. SPAN, 60 FEET. BUILT FOR COVENTRY ORDNANCE WORKS BY RANSOMES & RAPIER, LTD., IPSWICH



OVERHEAD TRAVELING CRANE. ZOBEL, NEUBERT & CO., SCHMALKALDEN

ELECTRIC LADLE CRANE OF 60 TONS, 17.7 METRES SPAN. ZOBEL, NEUBERT & CO., SCHMALKALDEN.
(T. & E. WANNBACHER, AGENTS, LONDON)



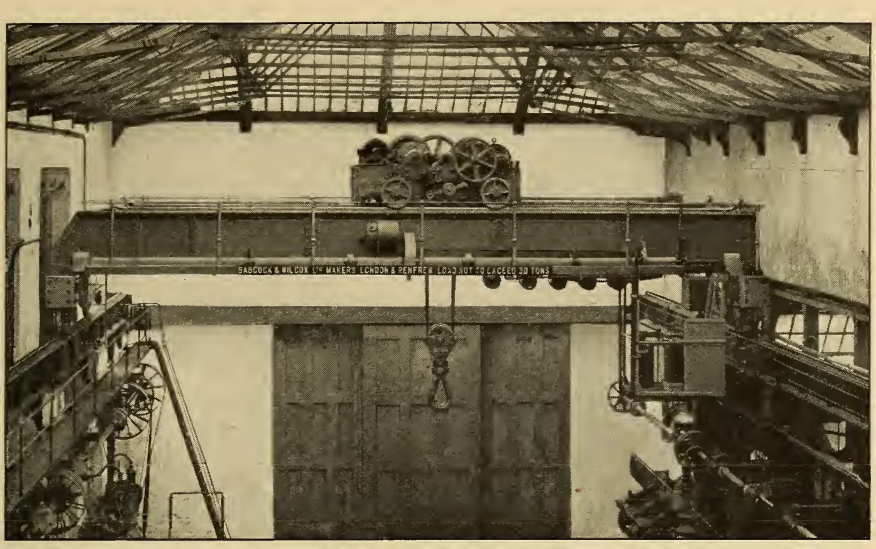
ELECTRIC TRAVELER OF 5 TONS CAPACITY WITH ROTARY SUSPENDED JIB FOR USE IN IRONWORKS. ZOBEL, NEUBERT & CO., SCHMALKALDEN

diagonal bracing. The loads are not usually great, but all the speeds are high.

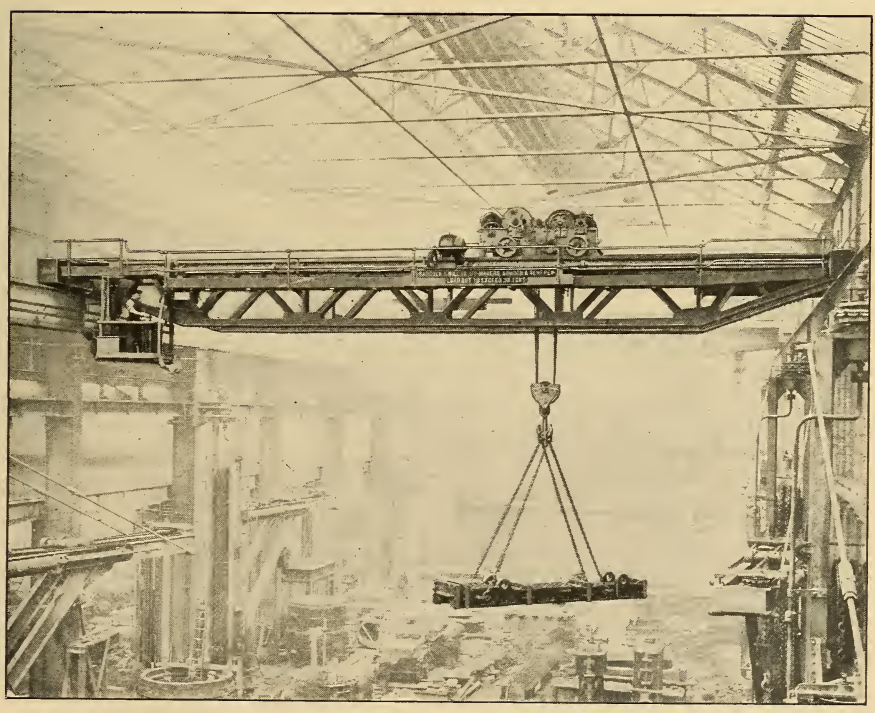
The bridge girders are united at the ends with end cradles or carriages, these being the short girders which carry the bearings for the traveling wheels. These carriages are weakening elements in a traveling crane unless they are made long enough to give a good wheel base, and are united firmly enough to the main girders to prevent risk of their working loosely.

The amount of head room determines the location of the end girders in relation to the main girders. There are four ways in which they are attached. If head room is ample, then the main girders may be riveted down directly on the top edges of the end girders. If the room is sufficient, the ends of the main girders are abutted against the sides of the end girders. This is by far the commonest design. A modification of the two methods is frequent, and is very strong and secure. In this the main girders are shouldered so that they partly abut against, and partly rest on the end girders. An unsatisfactory method, though sometimes necessary when the head room is very low, is to hang the main girders below the end ones. Whenever there is plenty of head room, and in outdoor work, as in timber yards, pig beds, stocking yards, etc., the best design is that in which the traveling girders rest on the end carriages and are wholly above them, the top flanges being connected with bracings and the crab running on the bottom flanges. Such cranes may be traveled at high speeds, as high as 400 feet per minute.

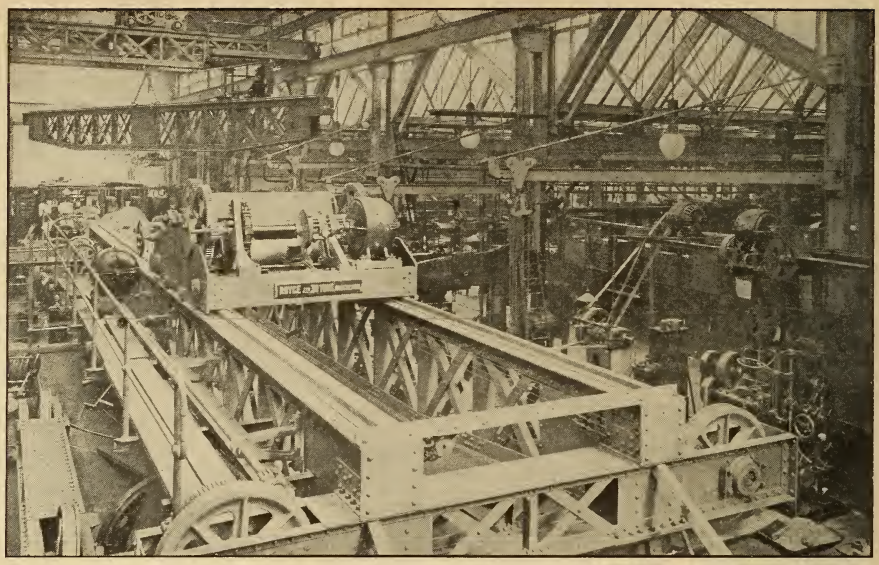
The strains on the end carriages are threefold: those due to the vertical load, those produced by cross traversing, and the racking strains incidental to traveling. These are very severe, and are usually the first to reveal their results in a poorly designed crane. An end carriage is loaded to the maximum when the crab fully loaded is at its end of the span. The weight is then



ELECTRIC TRAVELING CRANE, THREE-MOTOR, 36 FEET SPAN. SUPPLIED TO THE BRITISH ADMIRALTY FOR H. M. DOCKYARD, DEVONPORT, BY BABCOCK & WILCOX, LTD.

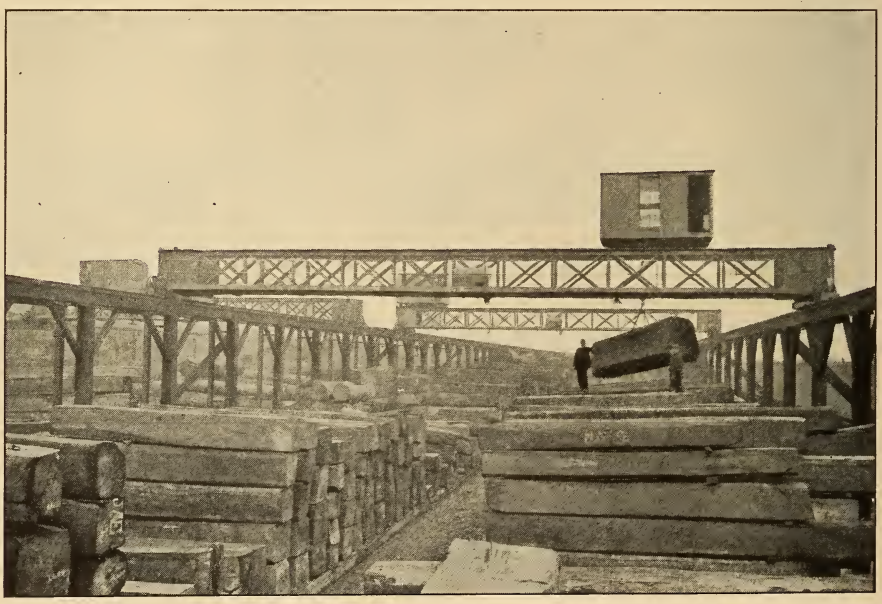


ELECTRIC TRAVELING CRANE OF 30 TONS CAPACITY, BUILT FOR GREENFIELD & KENNEDY, LTD., BY BABCOCK & WILCOX

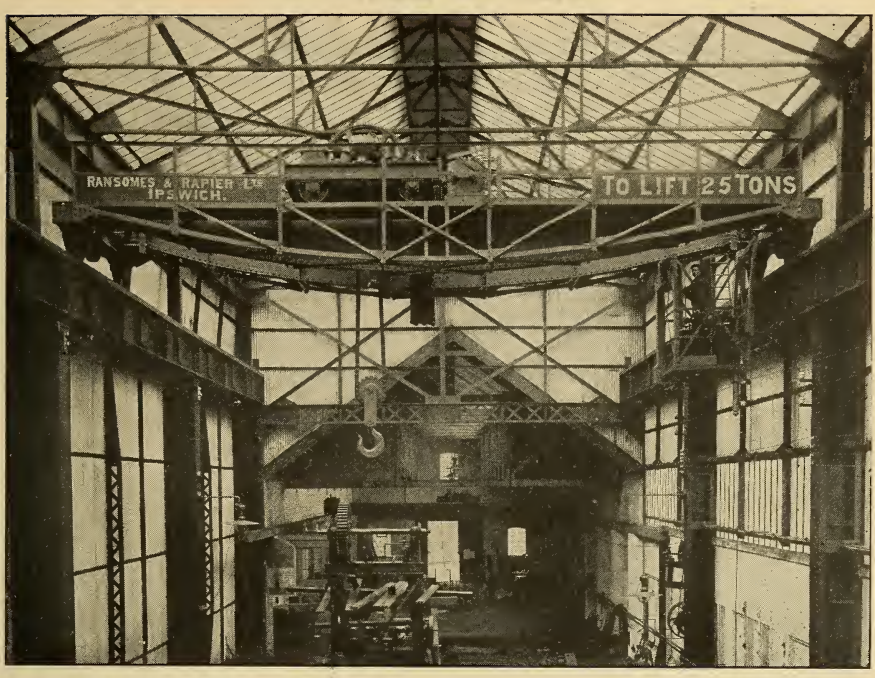


VIEW OF 30-TON ELECTRIC CRANE FOR JAPAN, ERECTED FOR INSPECTION IN THE WORKS OF THE BUILDERS, MESSRS. ROYCE, LTD., MANCHESTER

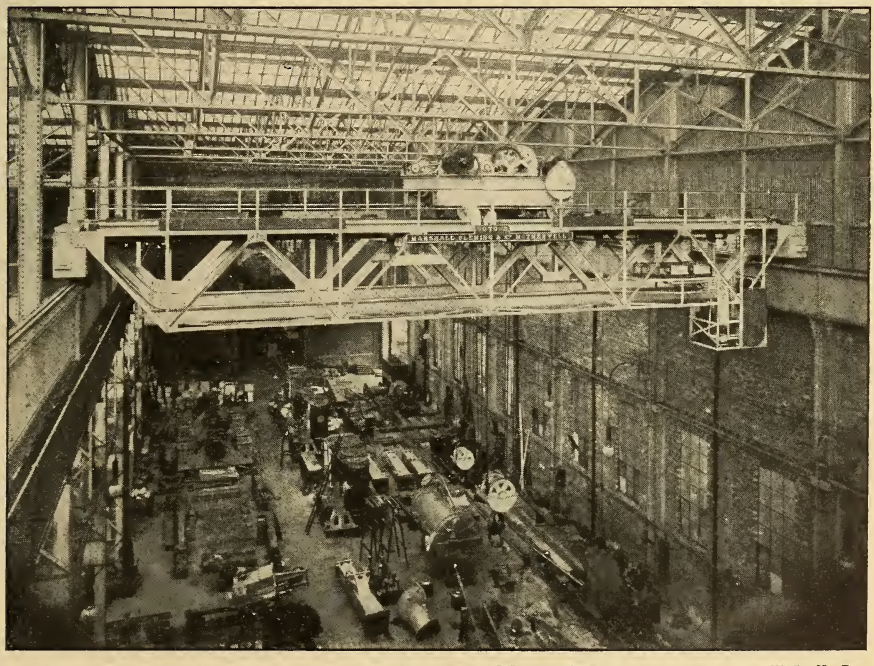
that of the crab and its load, with half the weight of the girders. This does not impose the maximum load on the main girders; but it does on the end carriages, to be borne by their girders and by the traveling wheels. These wheels and their bearings are, therefore, very severely stressed in heavy cranes. Lateral stresses are set up in the end carriages by the cross-traverse movements of the crab, especially at starting and stopping, with the full



THREE ELECTRIC CRANES, TWO OF 5 TONS AND ONE OF 7½ TONS, SPAN 65 FEET, AT MESSRS. FARNSWORTH & JARDINE, SEAFORTH. BUILT BY MESSRS. ROYCE, LTD., MANCHESTER



OVERHEAD ELECTRIC TRAVELING CRANE WITH COMBINATION OF SOLID AND PLATE GIRDERS AND PLATE CHAIN. CAPACITY 25 TONS. RANSOMES & RAPIER, LTD., IPSWICH



OVERHEAD ELECTRIC CRANE WITH AUXILIARY HOIST. MARSHALL, FLEMING & CO., MOTHERWELL, N. B.

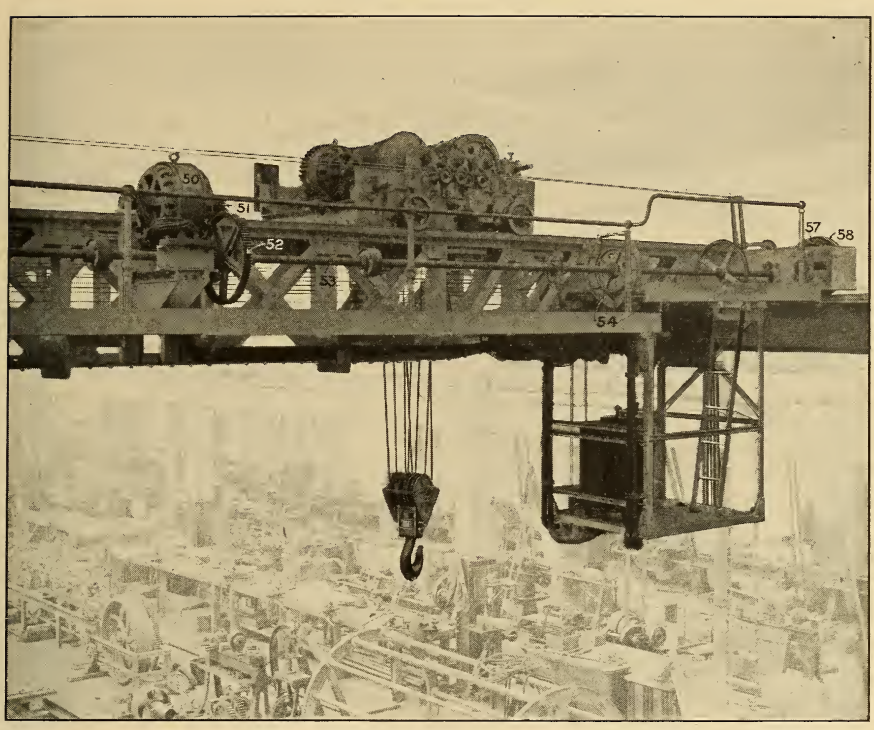
Hoisting speeds, 80 tons at 4 feet per minute, 40 tons at 8 feet, and 15 tons at 14 feet per minute

HEAVY LADLE CRANE OF 150 TONS CAPACITY, WITH AUXILIARY HOIST OF 25 TONS. BUILT BY WELLMAN, SEAVER & HEAD, LTD., LONDON AND GLASGOW

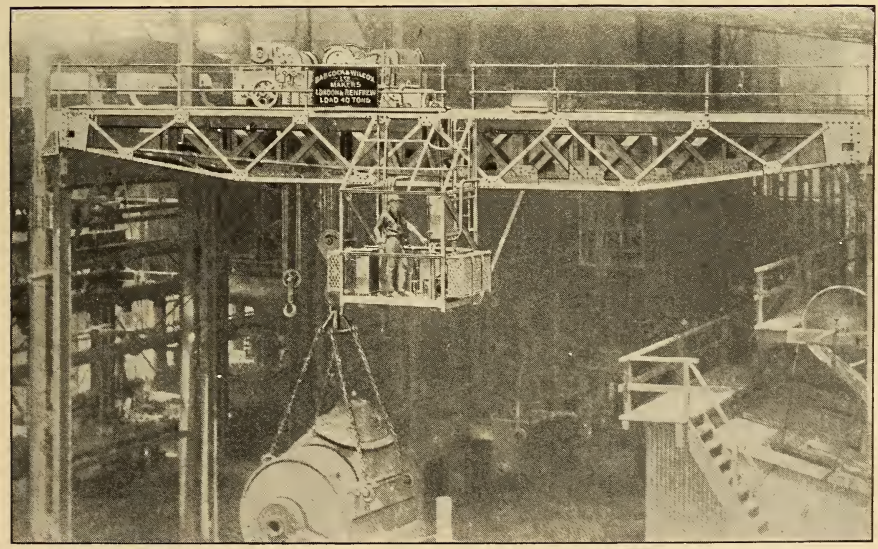
Main hoisting at 5 feet per minute, with 80-horsepower motor; cross traverse at 60 feet, with 35-horsepower motor; travel 100 feet per minute with 60-horsepower motor.

load swaying in the hook. Good width of girders is required to resist and absorb these stresses, together with secure fastenings to the main girders. These fastenings are of equal or greater importance from the other aspect, that of cross working of the entire framework, which risk increases with increase in width of span.

In general the wheel base of the traveling wheels is made proportionate to the span, usually about one to five. But that only provides one safeguard, in itself perhaps of less value than rigid connections, true wheels, and a true gantry track. Exactly how the connections are made is of less importance than close joints and ample riveting. Gusset plates are useful, covering the joints of girders and carriages, and extending to the ends of the latter. Rivets should fit closely in reamered holes. Cross working will result if the traveling wheels are not all of exactly the same diameter, and if the rails are not level and parallel. The wheel treads must be turned, and re-turned when they wear slightly. They should be of cast steel, or preferably have forged steel tyres shrunk on cast centers. Only by care in making and maintaining wheels and track line true can cross working be avoided. Four traveling wheels are employed, except in the case of the heaviest cranes, where more are sometimes used. The journal bearings are either dead eyes, that is, solid and bushed without means of adjustment, which is only suitable for the lightest and cheapest cranes, or divided bearings of the axle box type are used. The wheels are driven from spur gears, one set of driving gear being located



OVERHEAD PIG-BED CRANE AT GYERS, MILLS & CO., LTD., AYRSOME IRONWORKS, MIDDLESBROUGH.
BABCOCK & WILCOX, LTD., LONDON AND RENFREW



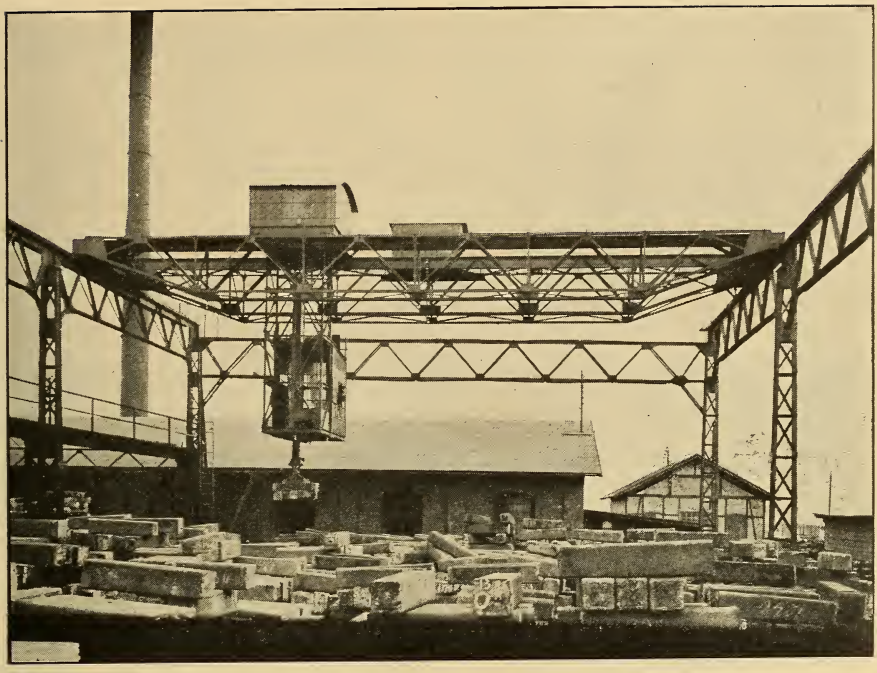
ELECTRIC TRAVELING CRANE OF 40 TONS CAPACITY WITH 10-TON AUXILIARY HOIST.
BABCOCK & WILCOX, LTD., LONDON AND RENFREW

OVERHEAD TRAVELING CRANE OF 10 TONS CAPACITY, 50 FEET SPAN. GEORGE RUSSELL & CO., LTD., BUILDERS, MOTHERWELL, N. B.

at each end of one of the crane girders. The other two wheels are followers simply.

On the traveling wheels, gears, and journals the stresses are very severe. Friction here absorbs power and wear tends in time to produce cross working. Neither solid nor ordinary divided bearings and ordinary lubrication are suitable for heavy cranes, but the axle box design with self-oiling bearings should be adopted. The system adopted in the Adamson heavy cranes, the illustration being from one of 100 tons, is as follows: The boxes fit into holes bored in the web-plates of the end carriages. In the heavy cranes a compensating beam is employed. Each box is lubricated with a floating roller kept directly underneath the journal by means of guides within the oil chamber. Access to the chamber is by a flap door at the side. The journals are made of different diameters in order to equalize the wear as much as possible, the one at the outer end of the traveling axle being the larger. In order to avoid keys in the gear wheel on which the leverage of driving comes, this is made solidly with the center of its running wheel, and the teeth are cut from the solid. The tyres are of steel shrunk on and turned on the treads.

A compensating arrangement by Marshall, Fleming & Co. is provided to ensure equal distribution of the load on the traveling wheels. The end carriages are made in halves with a hinged joint in the middle. Another feature is included which answers very well when heavy running wheels are in question. The wheels are not keyed on running axles, but run loosely on fixed axles. They are bushed with gunmetal and the axles bored through from the ends to receive Stauffer or needle lubricators. The mouth of the tube is turned up and is fitted with a screwed cap.



5-TON INGOT LOADING CRANE WITH SUSPENDED CAGE. ZOBEL, NEUBERT & CO., SCHMALKALDEN. (T. & E. WANNBACHER, AGENTS, LONDON)

OVERHEAD CRANE WITH SUSPENDED CAGE AND ELECTRO-MAGNET FOR STEEL WORKS. ZOBEL, NEUBERT & CO., SCHMALKALDEN

Fixed axles are also employed by Messrs. S. H. Heywood & Co., Ltd., and by some other firms. The driving gears are registered into the running wheels to ensure concentricity, and secured with turned bolts. These, in common with all the gears, are machine-cut from the solid by most firms.

As the gantries have to take the dead and live loads of the loaded crab and traveling girders they must be strong enough and rigid enough both

OVERHEAD ELECTRIC TRAVELING CRANE OF 7½ TONS CAPACITY, 68 FEET SPAN. GEORGE RUSSELL & CO., MOTHERWELL, N. B.

in the vertical and lateral directions to resist all stresses which can be imposed on them. The girders must be supported by means either of columns, or of corbels at suitable intervals, so that there shall be no flexure at intermediate locations, and they must be wide enough to resist lateral surges due to the cross traverse of the loaded crab. Usually solid-plated box girders are employed for heavy cranes, rolled joists or lattice-braced girders for the lighter ones. They carry heavy rails of bridge section which must be laid truly level and parallel.

When the hoisting element of the machine carries all the operating mechanism for lifting, and in some cases the operator also, the term "crab" is used to distinguish it from a "trolley" or "jenny," which only carries the hoisting drum. Speaking generally, the most powerful machines are fitted with crabs, the lighter ones with trolleys, but that is only true as a general statement. It holds good of most of the electric travelers, and most of the steam travelers, but not of the cotton-rope type. In electric cranes, too, much depends on the nature of the service. Where it is very intermittent in character, sheer waste of time would be involved in keeping a man on the crab, and then even heavy cranes are more economical if operated by dependent ropes or chains from below. Neither is it essential that the attendant should be where the operating mechanism is located. That is the case in those steam crabs which carry the boiler and engines on the crab framings. But it is seldom so in electric crabs, which are mostly operated from a cage below the bridge gir-

ders. This is done when the service is practically continuous, when there is no advantage in operating from the floor.

The construction of the crab framings is as light as is consistent with strength to handle maximum loads. Crab sides are of steel plate, double in the heavy cranes, single in the lighter. The shaft bearings are castings fitted to these by bored holes, brass bushed. They are always, therefore, solid-plated, being too small for lattice-braced work. Formerly cast iron was used for the framings, which took the form of cheeks. This practice was and is still common in the steam crabs of small and moderate powers and in electric cranes, but for the heaviest, plated cheeks are made. The shapes of the frames for electric crabs, and of the cheeks for steam crabs, are different. In the first a level bed of plates on a low framing carries most of the mechanism, in the second the cylinders are bolted to cheeks which stand considerably higher. In the first the gears are mostly carried above the top of the framing, in the second they lie largely between the cheeks.

The running wheels are made similarly to those of the traveling bridge, but are smaller, and have less load to carry. But they are cast, or steel tyred, and are turned, and their axles carried in solid, or in divided bearings.

The trolleys, or jennys, are hoisting elements which, if operated by power, are separated from the source of power, which is transmitted to them through chains or ropes. There are few electric trolleys used on overhead cranes, but mostly crabs. In a very few steam cranes of old designs the boiler and engines have been located at one end of the bridge, and the power transmitted thence to the trolley both for lifting and traversing. The same method is adopted in the block-setting cranes, and in most of the hammer-head cranes. In the hand travelers either a crab or a trolley is used, the latter being worked from the floor.

With regard to allowances for stresses generally made by firms, the stress on the girders with maximum load will not exceed 5 tons per square inch of the net flange area, or 4 tons per square inch on the modulus of section. The deflection of the main girders will not exceed ⅜ inch under maximum load. The maximum stresses on any member under full working load does not exceed 5½ tons in tension on net sectional area, or 4½ to 5 tons to compression, and 3 to 4 tons to shear. For shafts, 4 tons on the modulus of the section. For cast iron 5 tons per square inch in compression, and 2 tons in tension, except in the case of the rope-drum, for which a maximum tensile stress of only 1 ton per square inch is allowed. For the crane generally a factor of safety of 6 is allowed, for the wire ropes 8.

THE DEVELOPMENT OF THE AMERICAN STEEL INDUSTRY

By W. A. Day

A FEW years ago Andrew Carnegie made the startling statement: "In the next five years the United States will make more steel than the whole world besides." From the furnaces of Germany, the largest European steel maker, now come about 12,000,000 tons in a year. If to this is added the product of the British and other works, a total of about 22,000,000 tons is found to be the total. During the last fiscal year the American steel plants yielded over 23,000,000 tons, or more than all the works of Europe combined.

The causes which have led to this tremendous production are many, and the methods which have made it possible are worthy of general examination. It is very largely due to the increased efficiency of modern steel-making processes, derived from the application of the results of chemical, physical, and metallurgical investigations, combined with mechanical ingenuity, which has made practical the American steel industry of to-day. The iron which comes from the blast furnaces is passed through what is practically a continuous operation, performed wholly by machinery, until it appears as open-hearth steel, in the form of finished rails, coils of steel wire, bars, rods, or structural shapes. The operations of melting, mixing, soaking, rolling, drawing, and finishing are conducted so systematically and efficiently, that every form of steel product demanded by the industry of the world may be produced, and enter the markets of all countries in competition with the local product.

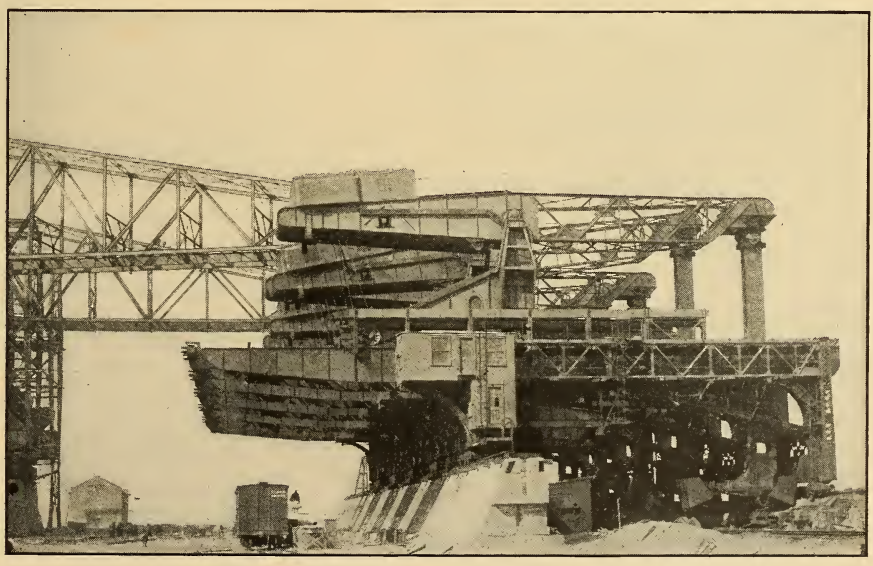
In examining this subject it is necessary to give some consideration to the question of raw material. Examinations made by geologists and mineralogists has thus far shown that the Bessemer grades of ore, so far as exported, are being decreased rapidly by reason of the demand for this grade of metal, while deposits of lower grade, suitable for open-hearth steel, are found in deposits in Alabama and other Southern States, in the Superior iron ranges, and even in northern New York and Pennsylvania. The southern and western deposits are so extensive as to be inexhaustible. The fact that the open-hearth process now in such general use in steel making can produce a metal for as many, if not more, purposes than the Bessemer grade, has caused attention to be attracted to these great beds of low grade ore, since nearly all of them contain a sufficient percentage of metal to allow it to be extracted in the furnace and converted into steel by the open-hearth method. In 1911 there were made in the United States about 8,000,000 tons of Bessemer steel, and more than 15,000,000 tons of open-hearth steel, according to the American Iron and Steel Association. The use of open-hearth steel in rails, buildings and bridgework, implements and machinery, has proved its strength, durability and tenacity, while it is adapted for a wide variety of work. By the open-hearth process the billets produced are more compact and have fewer air cells in them than steel rolled by other methods. Such are the principal reasons why in the last five years more than $100,000,000 has been appropriated in this country to build and equip open-hearth plants.

On the shores of Lake Superior, at the very edge of the great ore ranges, mills and furnaces are being con-

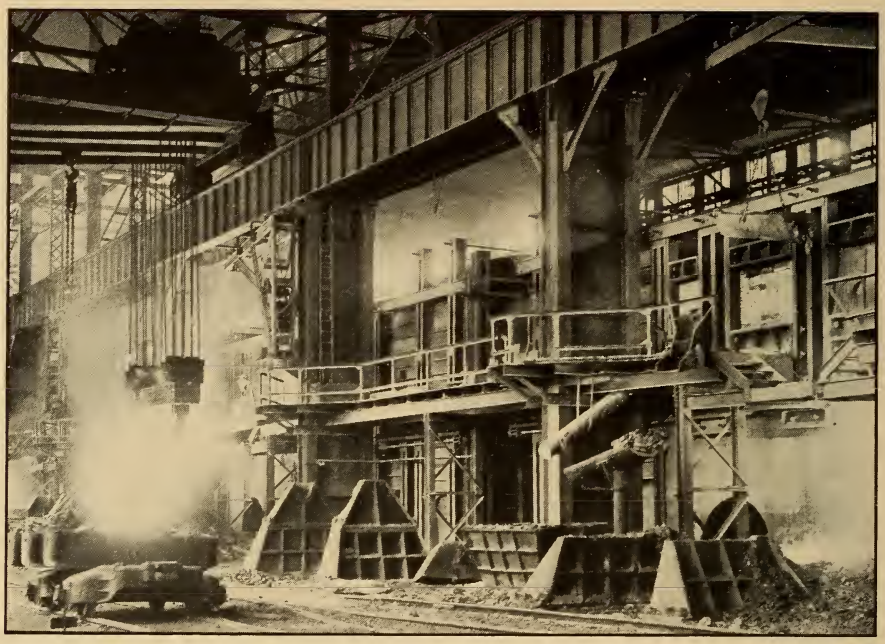
STREET VIEW IN GARY, INDIANA, A CITY OF 20,000 INHABITANTS CREATED BY A STEEL WORKS

structed which will cost $25,000,000—the estimates of the architects and engineers. On the Chesapeake Bay, the Maryland Steel Company has completed new furnaces that produce metal enough to roll nearly 500,000 tons of open-hearth rails annually. Ten million dollars have enlarged the works of the American Birmingham in Alabama, because here the demand for this kind of steel has caused its owners to double the capacity of the plant.

The most notable illustration of this activity is shown at the city of Gary, Ind. Here the United States Steel Corporation has designed the largest individual steel works in America.



ORE UNLOADERS AND BRIDGE CONVEYOR TO STOCK YARD AT THE GARY STEEL WORKS



POURING OPEN HEARTH STEEL AT THE GARY WORKS

The annual production of iron which will be the basis of steel will be nearly 2,500,000 tons, coming from 16 blast furnaces when this part of the plant is entirely completed. Steel is made in six different furnace buildings from 54 open-hearth furnaces, each having a capacity of 60 tons, making a total steel capacity of 3,750,000 tons in a year. Associated with the steel production are a billet mill and a rail mill, the latter turning out 4,000 tons of rails a day, in addition to plants for making steel plate, axles and other commercial forms. The machinery utilized in the steel furnaces, the billet and rail mills and the auxiliary plants is actuated entirely by electric motors of various types in addition to a substation, illuminating the city of Gary, which has a population of 20,000 people.

These figures will give an idea of the enormous amount of electrical horse-power which is required. It may be said here that the main power plant will generate no less than 120,000 horse-power, compared with only 45,000 steam horse-power needed for special processes in which electricity cannot be used. The electric generators are driven by a series of 17 twin-tandem gas engines, directly connected to the generators. The current transmitted is utilized not only for other industries referred to, but also for unloading the ore to the stock pile or direct to the furnace.

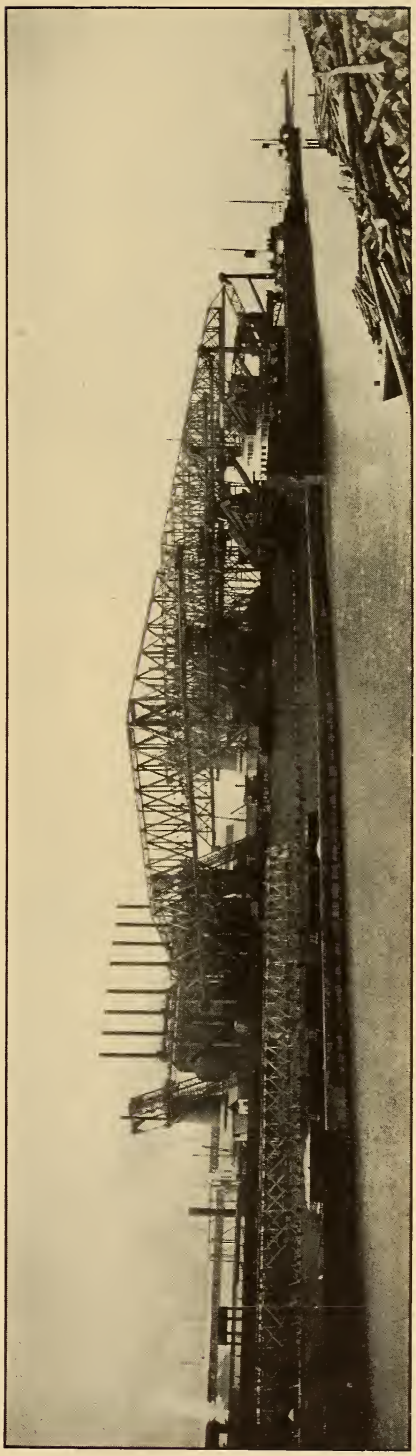
The elaborate electrical system is one reason why the works at Gary form a model in the economical and efficient production of steel. The raw material brought from the Superior mines is unloaded in Gary harbor entirely by electrical power actuating a series of 10 unloading machines of the Hulett type. The machines have a combined unloading capacity of 1,100 tons of ore per hour. Working in conjunction with the Hulett unloaders are ten traveling conveyor bridges. These structures are about 500 feet long. They extend from the concrete trough into which the Hulett unloaders discharge across the whole width of the stock yard. Each bridge is provided with a 15-ton grab bucket, by which the ore is picked up from the trough

and deposited in the stock pile, from which it is picked up again as it is needed and loaded into the blast furnace supply cars. In the operation of the bridge tramway it is supported on two towers, mounted on trucks, by which it can be moved up and down the wharf on a track.

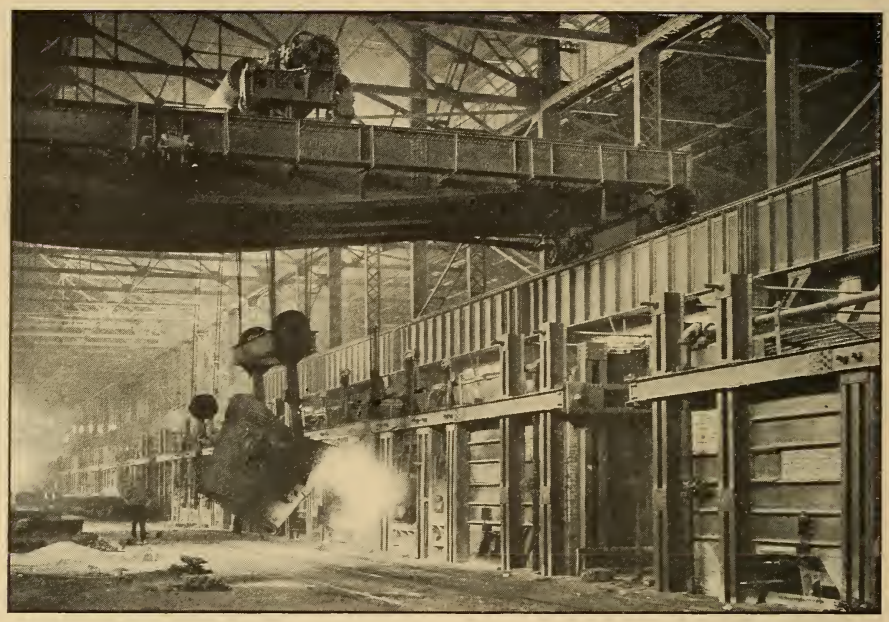
The electrical equipment for this work includes 130 horse-power reversible motors, which operate the bridge-car haulers and operating drums. The car-haulage drum is of two diameters, 5 feet and 8 feet, respectively, so arranged that the haulage rope is wound on the smaller drum while the car is being pulled up the steeper part of the incline; and when the car reaches the more level part of the track, the rope, by means of a spiral groove, passes to the 8-foot drum, which gives greater speed. The drums for operating the buckets are 5 feet in diameter. Heavy friction clutches and powerful band brakes for each drum are provided.

For moving the bridge back and forth along the stock yard, electric-driven mechanism is supplied, connecting both the machinery tower in front and the shear leg at the rear. The driving gear for this moving mechanism is located on one end of the intermediate shaft. The connecting gear is operated by a jaw clutch and is bronze bushed for running loose on the shaft. Branch shafts for connecting all the trucks of machinery tower and shear legs are driven from this gear. The bucket car haulage mechanism is arranged to dump one car at the extreme end of travel and return it to the transfer car, making a complete cycle in one minute. The vertical hoisting speed is 175 feet per minute, and the cross travel 600 feet per minute, while the bridge travels along its track at the rate of 75 feet per minute.

In serving or feeding the blast furnaces transfer cars operated by electricity are utilized entirely. Back of the stock yard, which will hold 5,000,000 tons of ore, is the blast furnace plant, each with its equipment of four hot-blast stoves. The blast furnaces

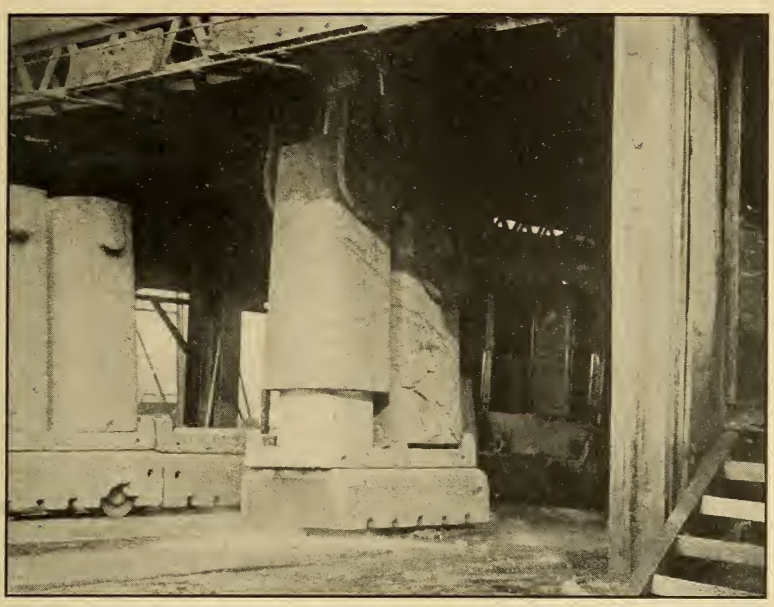


VIEW OF PORTION OF GARY STEEL PLANT, SHOWING BATTERY OF IRON FURNACES, HOT-BLAST STOVES, CONVEYOR FOR COKE OVENS (ON LEFT) AND CONVEYORS FOR ORE AND UNLOADERS FOR ORE BOATS (ON RIGHT)



OPEN-HEARTH STEEL FURNACES SERVED BY ALLIANCE ELECTRIC CRANE AT THE GARY WORKS

are 88 feet in height from the tap hole from which the hot metal is drawn to the top of the furnace lining, and the capacity of each is 450 tons per day. Between the stock pile and the furnace is a long line of elevated storage bins arranged in two parallel rows. One row is for coke and the other for ore and limestone. Above the bins are four tracks on which travel two 60-ton electric transfer cars. The ore is loaded into the transfer cars by buckets of the overhead ore bridges. The coke and limestone are brought up over the bins by rail and deliver their load directly by gravity. At the bottom of the bins are spouts controlled by electrically operated gates, and below these are tracks which run the full length of the bins. Traveling on these tracks are electrically operated lorries into which the ore, coke and limestone are delivered from the bin spouts. The lorries carry the materials to what are known as the "furnace skips," of which there is a pair to each furnace. The skips run upon an inclined railway which runs direct from a pit below the transfer cars to the charging platform at the top of the blast furnaces. Each trip of the skip is made in about 60 seconds, and its average load consists of about 7,000 pounds of ore, or 6,000 pounds of limestone, or 3,600 pounds of coke. The operator merely starts the skip on its journey. Its movement up the incline and the halt at the charging platform above are controlled automatically. The electric current for this purpose is transmitted by an overhead system, the motors ranging from 40 to 60 horse-power each. A large proportion of the conveying machinery at Gary was installed by the Alliance Machine Co., of Alliance, Ohio. This includes 144 electric traveling cranes, charging machines, strippers, etc., this number including three 150-ton four-girder ladle cranes, six 125-ton four-girder ladle cranes, and six 75-ton four-girder ladle cranes, these being installed in the various open-hearth departments. In addition are three 75-ton four-girder cranes in the metal mixer buildings, and 75-ton four-girder ladle cranes in the pig-casting department, five 200-ton electric stripping cranes to strip molds from ingots, five 10-ton vertical charg-

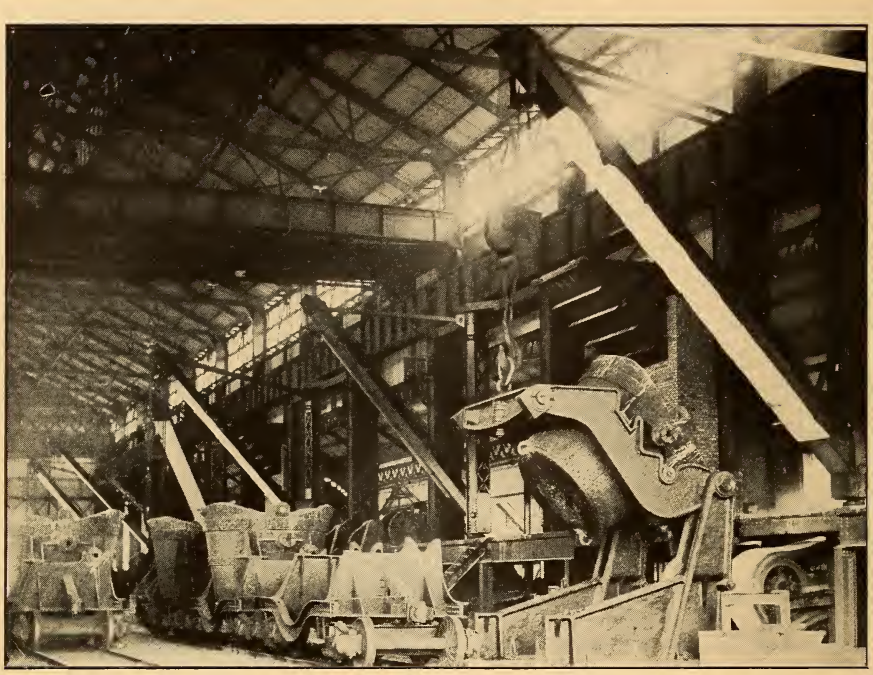


STRIPPING THE MOULD FROM A STEEL INGOT WITH AN ELECTRIC CRANE

ing machines or soaking pit cranes to charge and draw ingots from the soaking pits and deliver them to the roller tables of the rail mill or merchant mill, seven 40-ton special skull cracker cranes, 15-ton ingot crane, two special slab-charging cranes, besides bucket cranes, special rail-handling cranes and standard cranes, all made by the Alliance Company.

As already intimated, the system of making open-hearth steel could not be

CARRYING A HOT INGOT FROM SOAKING PIT TO ROLLING MILL



LADLE CARS AND CRANES AT THE GARY WORKS

introduced at these works were it not for the use of electricity in operating the furnaces. In converting the iron into steel, the metal is drawn from the bottom of the furnaces into 40-ton ladles, mounted on massive eight-wheeled trucks, which are hauled successively beneath the pouring spout. When a train of ladles is made up it is hauled to the mixer building, which contains two huge receptacles, each of 300 tons capacity. Into these the ladles discharge the hot metal, and the mixing of the product of the different furnaces insures a uniform average of composition of the metal. From the mixers, which are arranged so that they can be rocked or tilted, the molten metal is poured into 60-ton charging ladles, which are conveyed to the charging side of the open-hearth furnaces on electric transfer cars. From these cars the ladles are picked up by a 75-ton traveling crane and the metal is poured into the open-hearth furnace through a runner. The traveling crane referred to, as well as the ladles, are actuated by electric motors, and but one man is necessary to control the movements of each ladle and to empty the charging ladles, merely manipulating a series of levers, while the traveling crane is operated by one man.

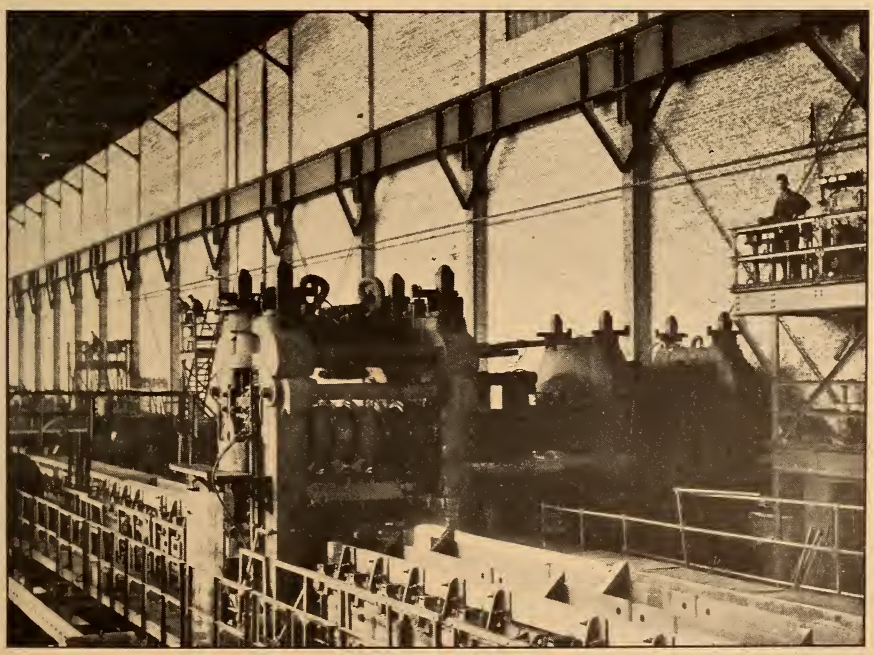
Tracing out the process to the billet mill, where the molten steel first assumes form, the equipment here consists of four 40-inch blooming mill stands, each pair driven by a 2,000 horse-power electric motor, and a five-stand continuous 32-inch mill driven by a 6,000 horse-power motor. Beyond this are two blooming shears 12 × 12 inches and 10 × 10 inches. Next, the blooms go to a 24-inch six-stand continuous mill, driven by a 6,000 horse-power motor, or to a pair of cooling beds for shipment. In this mill is employed one of the largest individual types of motor at Gary—an induction motor of special design for this service. This power is necessary on account of the enormous force which is developed in rolling the billets into forms for making into rails. The rail mill, which is adjacent to the billet mill, is equipped with roll trains

for shaping the rails, the power being furnished by three 6,000 horse-power and three 2,000 horse-power induction motors having a capacity for turning out 4,000 tons every twenty-four hours. The electric motors and the equipment were designed by the General Electric Company.

One of the most interesting features in connection with the generation of the electric current is that the source of power is not coal, but the gas discharged from the blast furnaces. One of the greatest economies in connection with the modern production of steel is the utilization of the gas which in the older plants is largely wasted. So much of this is obtained at the Gary furnaces that in addition to the development of 120,000 electrical horse-power, as already stated, 64,000 ordinary horse-power is available for blowing the furnaces. The total gas generated in smelting the ore is equal to 250,000 horse-power. Of this 30 per cent. is used in the heating stoves, 7½ per cent. for generating steam for minor purposes, 12½ per cent. in the blowing engine plant, while no less than 45 per cent. is converted into electricity. This is one of the most economical features in connection with the Gary works, since the electric current can be generated by means of the gas engines at a comparatively low cost. The engines number 31 in all and were from the works of the Allis-Chalmers Company, of Milwaukee. Gary represents the latest and most complete equipment for the various processes that convert the ore into the finished steel.

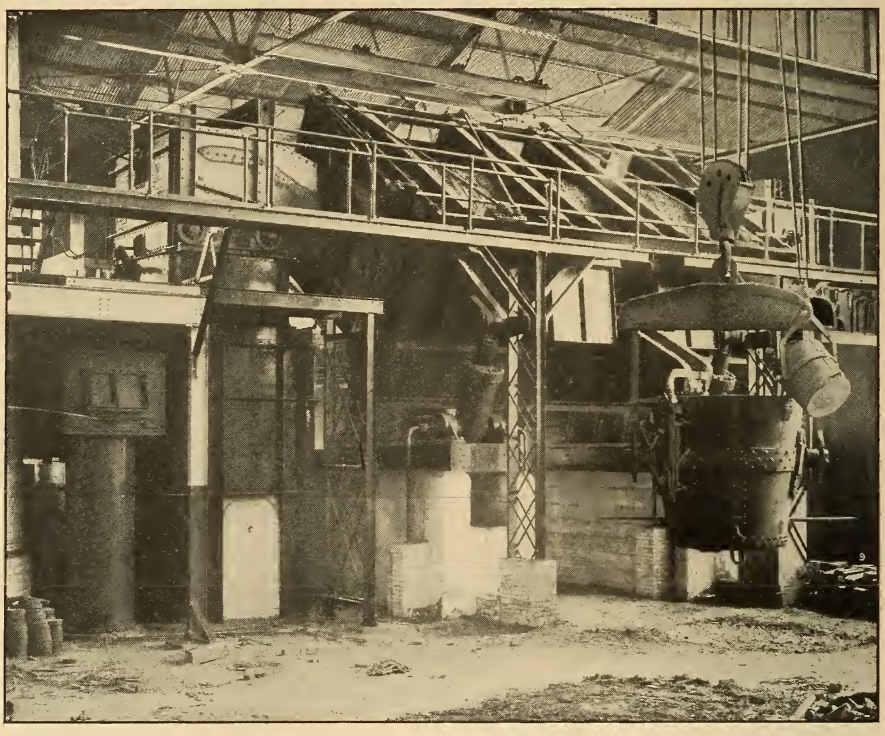
The new works at Duluth, Minn., in proximity to the great ore ranges of the Superior region, are modeled after the Indiana works. On a site of 2,000 acres, including a harbor front, the plant is being completed. It not only will include two blast furnaces, six open-hearth steel furnaces, blooming and rail mills, also a slag cement factory and coke ovens for making gas, also for power and furnace fuel. The total cost of this plant will be $14,000,000. The company acting for the United States Steel Corporation is entitled the Minnesota Steel Company.

It was to be expected that the sites



THREE-HIGH ROLLS AT THE GARY RAIL MILL. ONE MAN HAS ELECTRICAL CONTROL OVER EACH SET

of the new plants of this kind would be where water and land transportation are both available. Gary, on Lake Michigan, the plant on Lake Superior, and the Lackawanna steel works at Buffalo are illustrations of this fact. Like Gary and Duluth, the others are equipped with the latest



A TILTING FURNACE AT THE ENSLEY STEEL WORKS

type of mills and furnaces and the processes are actuated by electrical motors.

The era of steel making in the Southern States dates from 1898. Such was the success attained that in 1906 plans for enlarging and modernizing the Ensley works were begun. The Bessemer building is exceptionally large. The main proportions are 85 feet in width, 262 feet in length and 96 feet 10¾ inches in height to the apex of the ventilator roof. The converters and converter building floor are served by a 100-ton six-motor double trolley electric traveling crane furnished by the Alliance Machine Company, Alliance, Ohio. This crane has a span of 80 feet, and the lift of the main hoist is 45 feet 6 inches. Other conveying mechanism furnished by this company comprises one 145-ton four-girder ladle crane, four 100-ton four-girder ladle cranes, five 45-ton four-girder ladle cranes, besides coal larry cranes, bucket cranes, monorail hoists and standard cranes.

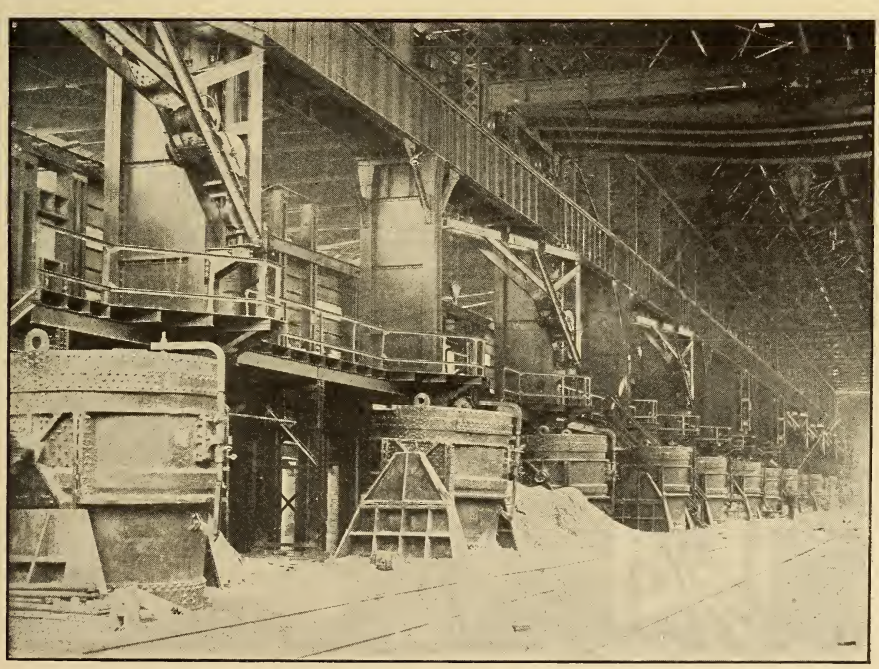
A spare converter is provided and a relining pit, and a change of vessels is readily made by the aid of the crane; trunnions which can be caught by the crane hooks being provided on the upper portion of the converter. There are two 20-ton removable-bottom converters with acid lining. These were built by the Pennsylvania Engineering Works, New Castle, Pa. For handling the ladles on the charging floor there are two 45-ton four-girder cranes, with double trolley and five motors. They have a span of 80 feet and a lift of 35 feet. The main

trolley has a 45-ton hoist operated by a 50 horse-power motor and an auxiliary hoist of 10 tons capacity. The liberal dimensions of the charging floor side, both as to height and width, afford excellent ventilation and add to the comfort of the workmen.

The pouring side is 52 feet wide and 459 feet long. It is commanded by two four-girder ladle cranes of 65 feet span, each equipped with double trolley and six motors. The main trolleys are of 100 tons capacity and each crane has an auxiliary trolley of 25 tons capacity. The bridge travel is 200 feet per minute and the track on which it runs is 29 feet 6 inches above the level of the floor. The crane hoist has a 35-foot lift.

There are two pouring platforms each 136 feet long. The ladles are of 100 tons capacity. When one of these is filled with molten steel it is lifted from its rest by a crane and conveyed to the pouring platform. The same crane returns it to the stand or carries it to be repaired. The drums of the 100-ton trolley hoist are spread in such a way that their cables do not interfere with the travel of the auxiliary trolley the full span of the crane bridge, and the crane manipulator is thus able to tip the ladle in either direction. Two charging machines of the Wellman-Seaver type are installed to serve the furnaces.

At the south end of the steel works yards is a skull cracker 150 feet long and 80 feet span, equipped with a 50-ton skull cracker crane with 25-ton auxiliary hoist. There is also a drop ball equipment and a lifting magnet 52 inches in diameter, the latter furnished by the Electric Controller & Mfg. Company, Cleveland, Ohio. The tracks are laid out for the convenient handling of material to and from the skull cracker, and a track scale is located midway outside of the plant for weighing of this material. To the east of the open-hearth building is the mold yard and directly west of the open hearth is the stock yard. Ore, scrap, limestone, dolomite and pig iron are brought in on standard gauge tracks and are stored in the proper bins and loaded directly into charging boxes. Charging box cars are



A SERIES OF OPEN HEARTH FURNACES, SERVED BY JIB CRANES AND ELECTRIC TRAVELING CRANE

HANDLING FINISHED RAILS BY LIFTING MAGNETS AT THE MARYLAND STEEL WORKS

weighed on track scales and transferred by locomotives to the charging floor of the open-hearth works.

Some details of the present method of operating under the duplex process at Ensley will be of interest. The hot metal from the blast furnaces is conveyed in 25-ton ladles to the north end of the mixer building, which is the end nearest the blast furnaces and about a mile distant from the farthest or No. 6 furnace. Having been weighed on track scales just before entering the mixer building the ladle is set on a platform beneath which is a hydraulic cylinder, which lifts it to the pouring platform of the mixer, located 31 feet 3 inches from the ground. The substitution of the hydraulic lift for the crane commonly used in serving metal mixers was with a view to greater safety. By means of a hydraulic ladle-tilting device the contents of the ladle are emptied into the 250-ton storage vessel. On the other side the metal to be blown is poured from the mixer into 20-ton ladles, which traverse the converter charging floor between the mixer and the converters. For pouring into the converter they are tilted by a hydraulically operated swing crane. This floor is 15 feet above that traversed by the 20-ton ladles which carry the blown metal from the converter to the open-hearth charging platform.

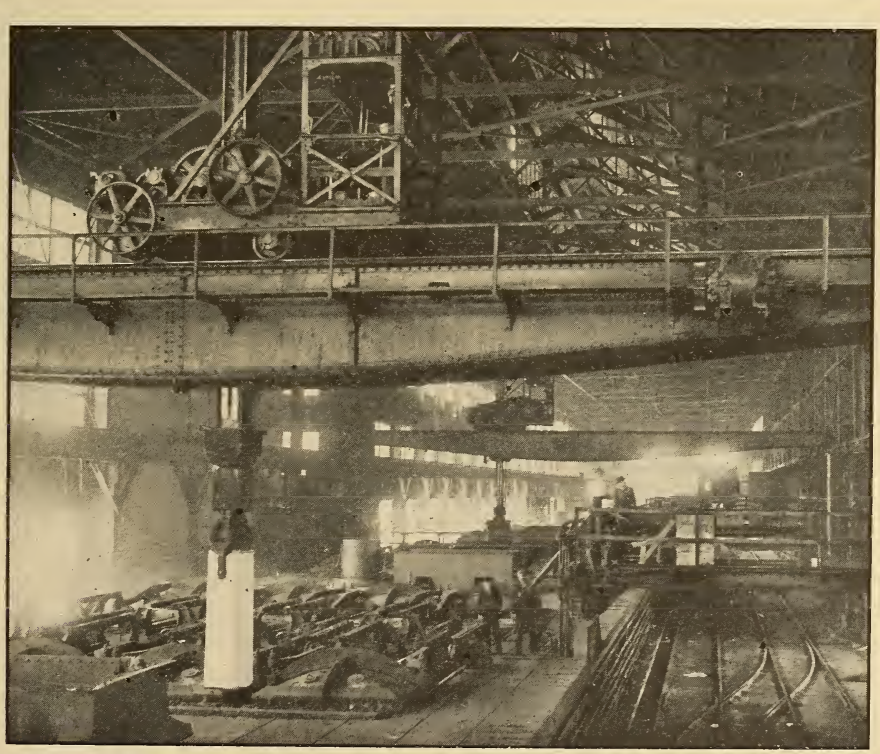
A 44-inch blooming mill and four four-hole soaking pits were a part of the original steel plant, and later a 27-inch three-stand rail mill was installed. The first open-hearth rail was rolled in November, 1902, and the Ensley rail, being of hard, tough, open-hearth steel, has been so successful that the demand was greater than the capacity of the plant. Then came the designing and installation of the new open-hearth and Bessemer steel works, and the remodeling of the blooming and rail mills and the finishing department of the latter. The new rail mill and the auxiliary equipment give a capacity of 50,000 to 60,000 tons of rails per month.

The works now include four 100-ton open and two 100-ton tilting furnaces, making a total of 600 tons daily. Blast is supplied to the Bessemer converters through a 30-inch air line by an Allis horizontal cross compound Corliss blowing engine, 46, 88, 84, and 60 × 84 inches, which is located in a steel and brick building separated from the Bessemer building by a battery of coke ovens and by the bottom house. The engine house is 160 feet long by 54 feet wide, and is provided with a 20-ton traveling crane. It also contains two Laidlaw-Dunn-Gordon flywheel pressure pumps, 27 × 34 inches, 34 inches 7¼ × 30 inches, furnishing water for operating the hydraulic cylinders at 550 pounds pressure, the speed being regulated by an attachment to the accumulator. Steam is supplied by four 500 horse-power Stirling boilers and four 300 horse-power Wickes boilers, the latter being located at the coke ovens and using the waste gas as auxiliary fuel.

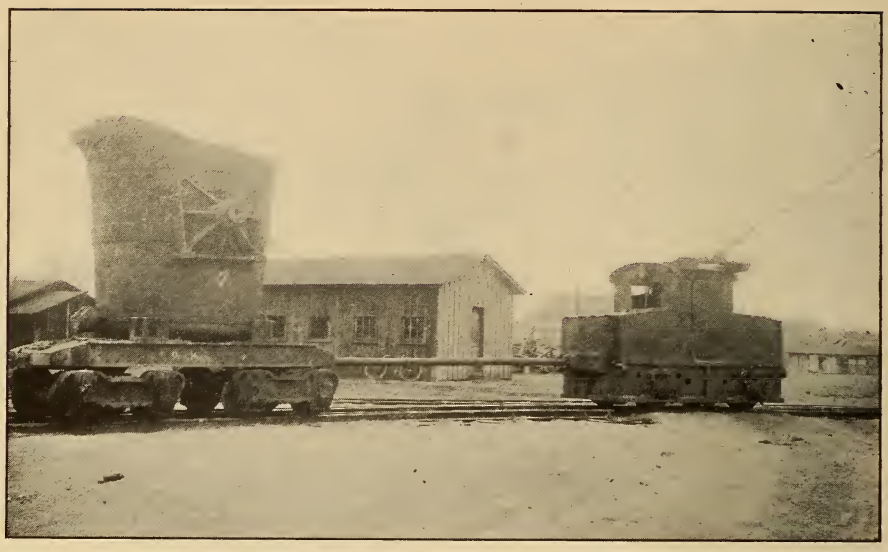
Gas for the open-hearth furnace is supplied through overhead gas mains from 20 gas producers, 10 feet 6 inches in diameter, built and designed by Alex. Laughlin & Co., Pittsburg, located in a building parallel with that containing the open-hearth furnaces. This plant is provided with coal and ash handling and storage facilities, which were built by Heyl & Patterson, Pittsburgh, Pa.

The original Ensley blast furnaces consisted of six stacks, three of which are of modern type, equipped with incline skips with steam hoisting engines, while three are hand-filled furnaces. The reconstruction of these latter furnaces was authorized, and they are replaced by three modern 400-ton capacity furnaces.

Ore and limestone are delivered directly from mines and quarries on cars to stock bins alongside the blast furnaces, and, as the operations are continuous the year round, the large ore storage noticeable in Northern plants



ELECTRIC TRAVELING CRANE HANDLING HOT STEEL INGOT OVER SOAKING PIT



ELECTRIC LOCOMOTIVE PUSHING A FIFTY-TON LADLE OF MOLTEN STEEL

is unnecessary, only enough storage capacity being provided to tide over interruptions in the supply. The bin system consists of a continuous row of pockets 1,072 feet long, built of wood and iron. A second double row of steel, ore and coke bins is now being constructed by the Pittsburgh Steel Construction Company. The ore bins are of the Berquist parabolic design, and the coke bins are provided with screens for removing the fine coke. The breeze-handling plant and its operation are as follows, after the design of the Jeffrey Mfg. Company, Columbus, Ohio:

There are two Jeffrey rubber-belt conveyors, an elevator, screen and structural steel storage bins, with facilitated for loading railroad cars on two tracks by means of chutes. The main conveyor, of 10 tons per hour capacity, starts underneath the coke bins, where screening plates allow the smaller sizes of coke to fall upon it. This belt conveyor, which is 18 inches wide, with 1,081 feet centers, discharges the material. The blast furnaces are supplied with two kinds of coke—namely, bee hive coke, which is supplied directly to the bins from the company's ovens located at the coal mines, two of the latter being inside the plant, and Semet-Solvay or retort coke. The Semet-Solvay plant consists of 240 by-product ovens located adjacent to the stockhouse, and their coke is delivered to the bins by electrically driven scale cars with a minimum amount of handling. The coke is transferred from the bins and dropped into skip cars by electrically driven scale cars. These run on a single track underneath the new steel ore and coke bins and on a second track under the wooden bins. Chutes are arranged to deliver the material from the bins to scale cars.

The new power station at Ensley replaces a direct current power house and generates current at a high voltage, which is transmitted at a minimum loss to a sub-station. Here, by means of a simple reducing apparatus consisting of rotary converters and transformers, the current is transmitted at 250 volts into the direct current system. The new alternating current electric power plant building is 54 feet wide by 180 feet long, is built of steel and brick, and is provided with a 20-ton electric traveling crane. The present equipment consists of three 600-kilowatts three-phase revolving field, 2,200-volt alternating Westinghouse engine type gen-

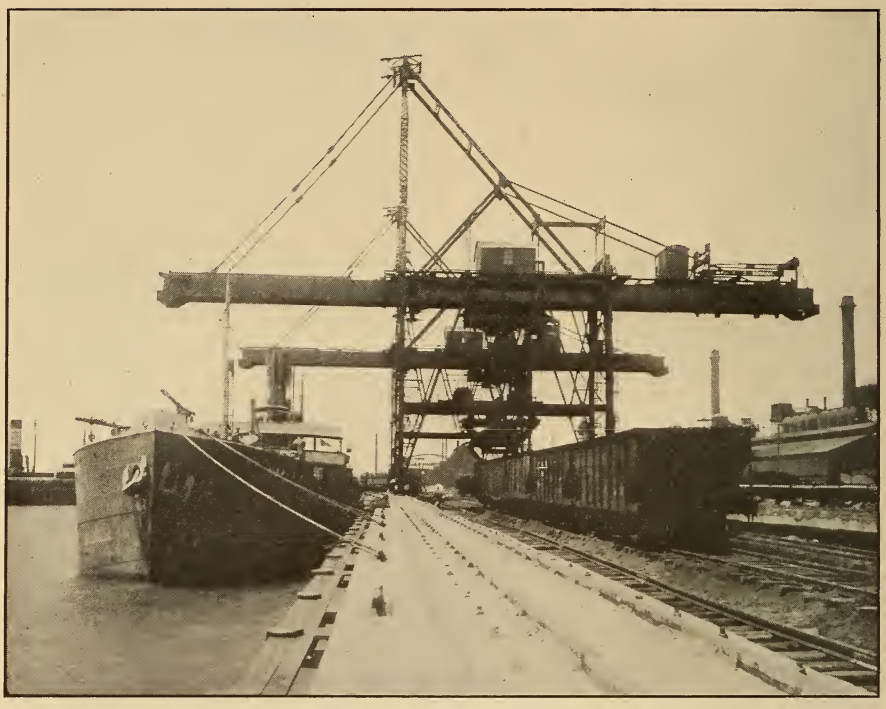
erators, direct connected to three 23-inch and 40 × 42-inch horizontal cross compound Corliss Wisconsin engines, running at 107 revolutions per minute.

Twenty years ago the Pennsylvania Steel Company, which controls one of the largest plants in the East, located by the ship load from the Daiquiri deposits in eastern Cuba, and steel for marine work from the plant at Steelton. Contrary to many other works there is no raw material in the vicinity available for steel making, no coal supply nearer than 250 miles; the ore

BRIDGE AND BUCKET FOR HANDLING IRON ORE. BROWN HOISTING MACHINERY CO., CLEVELAND, OHIO

at Steelton, Pa., found its business had increased to such an extent that it would be obliged to enlarge its capacity for production. The company decided to build another plant, and Mr. Frederick W. Wood, the superintendent of the Steelton works, was deputed to look for a suitable site. He found a tract of 500 acres on Chesapeake Bay, part farm land and part swampland. The advantages of the site were that a channel to the sea could be readily formed by excavating to deep water in the bay; by building a rail route a few miles long, connection could be made with the interior by the Baltimore & Ohio and Pennsylcania railroad systems. Rail and water transportation allowed coal to be brought from West Virginia, iron ore beds being more than 1,500 miles distnat.

The Maryland Steel Co. was organized as a division of the Pennsylvania Company, to build the Maryland branch at what is known as Sparrow's Point. Mr. Wood was elected president and the plant carried out and construction accomplished under his supervision. The original equipment included four blast furnaces, a blooming mill of the Bessemer system and a rail mill. Such were the economy and equipment of the original installation that the 400,000 tons of rails into which the yearly output of the Bessemer department is converted, have been sold for railways, not only in America but in many other parts of the world. Portions of the Trans-

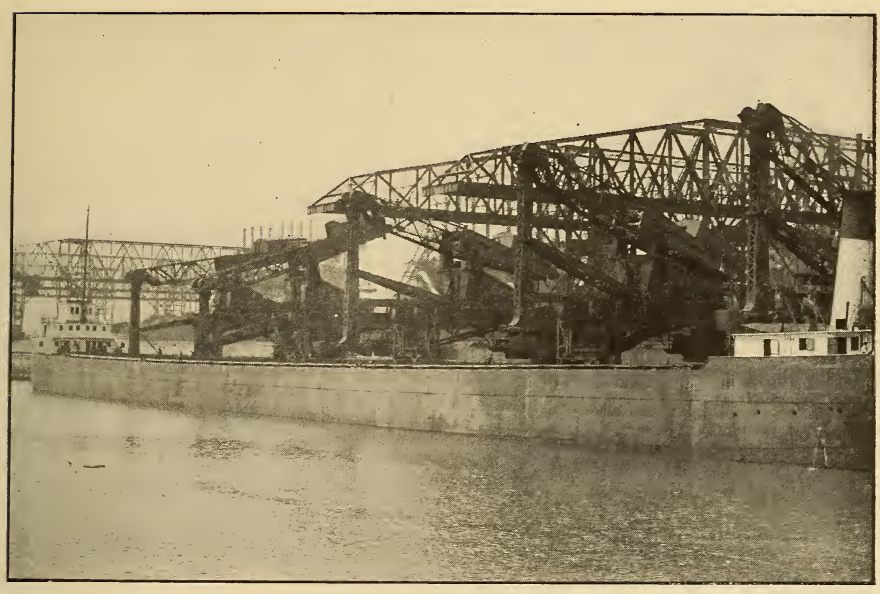


TRANSFERRING IRON ORE FROM BOAT TO CARS BY A BROWNHOIST CANTILEVER

Siberian Railway have been laid with them, as well as lines in Central and South America, the West Indies, Australia, South and East Africa and British India, and even in the heart of London, rails from the Maryland works have been laid down, forming a part of the underground railway system.

Its success in making rails at a cost which would allow it to compete in the foreign market, decided the company to engage in open-hearth steel making and a plant of equal capacity is now in operation for producing this grade. Besides steel, its gas production industry supplies this necessity for power also to half of the city of Baltimore for illumination, in addition to a marine plant that has built more types of craft than have been built at any other shipyard in the world, for not only have ocean steamships been constructed, but side-wheel and propeller steamboats for coast and inland waters, torpedo boat destroyers, passenger ferryboats for rivers and harbours, car ferries, dredges for deep-sea and shallow water, as well as steam yachts and tow boats. The marine department is separate from the dock department, where the two largest dry docks yet constructed for the United States have been completed.

The idea of the company from the first has been to utilize every device which would save time and labour in increasing the output, and when the open-hearth works were constructed the most modern apparatus was installed, including several originating with Mr. Wood. There is practically no delay in rail making from the time the ingot is moulded until the finished rail is loaded on vessel or car. The process is continuous. After the molten metal has been poured from the blast furnaces, it is conveyed to the open-hearth plant. These furnaces are of the tilting design. The steel is poured automatically from their vents so rapidly that the openings do not clog and the time



UNLOADING 5,000-TON ORE BOAT BY WELLMAN, SEAVER, MORGAN GRAB BUCKETS AT THE GARY WORKS

and labour of clearing them out by hand tools is avoided.

This is one of the original ideas employed here that has since been adopted in several of the newer plants. The castings of ingots has been really revolutionized. The former method of stripping an ingot from the mould was to put it out of the mould if possible by means of a power crane. Often the shell became so hardened that it could only be removed by breaking it with a sort of battering ram worked by human power. This has been one of the greatest drawbacks and delays in steel making owing to the great waste of time and labour. Mr. Wood, with the co-operation of the noted engineer, Aiken, designed a device by which one ingot can be stripped in 20 seconds, as shown by tests. It is performed so quickly that there is no shell to loosen, and the ingots are loaded on cars to be hauled by motors on a tramway directly to the next process.

The time for conversion of the steel does not exceed 15 minutes. This method increases the output 50 per cent. in a given time compared with the older method. Another reason for increase in production is the use of gas-soaking pits in which the steel is kept at an even temperature.

Electric cranes lift out the metal in ladles and place it on cars, to be conveyed to the next department also by electric tramways. The soaking pits are heated to 2,000 degrees and the metal remains in them 1½ hours.

The operation of the rail and blooming mills are also notable from the standpoint of time and labour economizing. The blooming mill contains 13 passes and the rail, 11 passes, making 24 operations in which the ingot is rolled and pressed into the finished product. The size of an 80-pound rail ingot is 5 feet in length and 21 × 29 inches in width and thickness. The passes move so rapidly that rails of these dimensions can be finished at the rate of 10,800 tons every 24 hours of continuous service, equal to a total length of 171 miles. Probably this record is exceeded by no other American plant. For loading the rails on shipboard or cars a pair of electric magnets are

employed which lift and deliver nine rails at one movement.

Some statistics will give a clearer idea of the extent of this industry. The furnaces produce 1,400 tons of iron in 24 hours, converted into 1,500 tons of steel. The blast furnaces require 1,500 horse-power received from four double cross-compound condensing engines. The capacity of the largest conveying crane is 75 tons and this average capacity of a tilting furnace ranges from 55 to 60 tons of metal. Electric current operates all the mechanism of the Bessemer and open-hearth departments. The aggregate horse-power in the former is 990 nominal horse-power, and the open hearth 2,962 nominal horse-power. The average consumption of current in the former department is 200 to 250 horse-power, and in the latter 300 to 500 horse-power, the great surplus of motor capacity over the average use being due to the irregular operation of electric cranes and other similar apparatus. The ore unloading machinery is of the Brown-Hoist type, served by General Electric motors of 530 horse-power. It operates 7½-ton buckets. All of the machinery in the steel works is actuated by electric motors supplied by the General Electric, the Westinghouse and the Alliance Machine Co., which installed a 50-ton special skull cracker crane, two 15-ton and two 10-ton single leg gantry cranes for loading rails.

Reference has been made to the source of ore supply of the Maryland Steel Company. The first investigation made by the experts resulted in a report that the available tonnage was limited to a certain period of years. More careful investigations later have revealed the fact that the beds of Eastern Cuba are inexhaustible and in area and quantity equal if they do not exceed the Superior ranges. The auxiliary company controlling the ore beds own 35,000 acres. Numerous tests from ore taken from various parts show an average of 25 tons of iron to the acre. From these and other estimates the mines now in operation contain no less than 700,000,000, averaging 55 per cent. of metal to a ton. Another great area as yet unopened is calculated to hold nearly the same tonnage—600,000,000 tons. This inexhaustible supply was the principal reason the works at Sparrow's Point were doubled in capacity by the erection of the open-hearth plant described.

According to the statistics published by the American Iron and Steel Association, there were made in the United States, in 1911, about 8,000,000 tons of open-hearth steel. While this exceeds by about 2,000,000 tons the total production of Europe, it must be remembered that many of the European works furnish steel of a much higher grade than that made in America, just as the higher grades of textile and similar fabrics made in the British, French, Swiss and other factories have not yet been equaled in America. The American steel product has passed that of Europe in quantity but not in quality, and the steel makers of Sheffield, in England, and at the Krupp works in Germany have reached a standard not yet attained in America. It yet remains for the American steel makers to bring the quality of their highest grade product up to the standard of the European establishments, and until this is done the market of such steel will be supplied largely from Europe.

SOME BASIC PRINCIPLES OF EFFICIENCY

By Henry Harrison Suplee

IN most of the discussions which have been held of late with respect to the much agitated question of efficiency, there has appeared a tendency to consider details of the conduct of the operation more fully than the underlying principles which really exercise controlling influences. This tendency is by no means a new thing, and many a careful and painstaking investigator has seen the results of his excellent work swept away by the removal of any cause for its existence, simply because he did not look deep enough, and devoted himself to the treatment of a symptom instead of the real ailment.

Many examples of this kind of mistaken effort will present themselves to the mind as soon as attention is directed to this phase of the subject, and it will be necessary to mention only a few examples. A careful examination of the underlying principles which affect the efficient conduct of industrial operations will reveal the enormous extent to which wastes may be avoided and expensive and difficult detail work often rendered unnecessary. A few such cases may be noted, as indicating broadly just what is meant.

The task of cutting a waterway through the Isthmus of Panama had long been projected, and after much investigation and deliberation the work was undertaken by De Lesseps and his successors in the light of the ablest engineering ability of a quarter of a century ago. The failure of that attempt has been ascribed to various causes, but even had it been successful it would have been accomplished at a great waste of life and money, largely because of the neglect of certain principles upon which the efficiency of the undertaking necessarily depended.

It was realized that the work would have to be done under climatic conditions for which Europeans were unfitted, but even with the experience of the Panama Railroad before them, little or nothing was done to prepare suitable sanitary conditions. Nevertheless, it was upon the suitable sanitation of the Isthmus that the efficient conduct of all subsequent operations depended, and the care which the United States Government later took to effect thorough sanitary control, including the elimination of causes of transmission of fevers and malaria, constituted the principal thing which made the efficient conduct of the actual construction work possible.

It may be said that it was not until recent years that the conditions of transmission of tropical fevers were discovered, but the fact remains that nearly two years elapsed from the time the work on the present canal was determined to the time when large forces of men and machinery were put into actual service, after the preliminary work of investigation of sanitary conditions and the preparation of proper control of health and physical efficiency. This is an excellent example of the true method of handling a great construction problem upon efficient lines; seeking the underlying causes of loss, and removing them before undertaking the perfection of details of actual work.

Another illustration of the extent to which careful preliminary work may affect later efficiency appears in

the planning of any new public service utility, such as a railway line, a telephone service, or an electric power station. Time and money expended upon a careful topographical and statistical study of the area to be served, together with the possibilities of its development and the directions along which growth may be expected, should, if conducted with proper foresight and judgment, have a controlling influence upon the plans subsequently prepared and executed in the actual conduct of the work. Too often it appears that the great railway station, constructed at a cost of millions, is in the wrong place, or is so inconvenient as to divert traffic instead of attracting it. The great hydraulic power plant is often placed at a point where engineering conditions indicate the possibilities of obtaining maximum efficiency, considered with respect to the generation of the power; while, after the plant has been constructed it may be found that market for the power is lacking, and that other unconsidered conditions render it difficult to attract customers. The latter, underlying condition was really the one which should have had most critical study before anything detailed was examined in connection with construction.

An illustration of the extent to which the idea of efficiency may depend upon the point of view of the individual administrator will be seen in the important matter of locomotive repairs in railway operation. The manager of the repair shop, acting wholly from the idea of shop efficiency, may seek to conduct the work of repairing a locomotive engine in such a manner as to cost the least amount of money, and he may feel that a maximum efficiency has been attained when the work, properly and satisfactorily executed, has been done at minimum cost.

The motive power department, however, counts the loss of the service of the locomotive as a charge upon the repairs, and reckons every day that the engine is off the road, as a direct and measurable money loss. If anything can be done to reduce the time during which the locomotive is out of service, even if this involves materially greater shop cost, it will greatly reduce the total cost of the disability and increase the final efficiency of the whole operation. Each department is right from its own viewpoint, and wrong from the position of the other, and it requires the broader consideration of the final result to enable the true efficiency to be obtained.

There is probably no one question of greater importance before the industrial world to-day than the scientific development of agriculture. The continual tendency of trained men to devote their efforts to work which, however valuable, does not act directly to produce the necessaries of life, is increasing the proportion of people to be fed as compared with the number occupied in producing subsistence. The theory of Malthus is apparently working itself out along a somewhat different line from that which its author could have foreseen, and it is probable that the solution will also be a different one from that which he offered. It is generally agreed that the demand for food can be met without undue advance in prices if methods for the cultivation of the soil similar to those which have been applied to the development of manufactures and transport are introduced. Intensive cultivation, using power machinery instead of human and animal power, and applied through the scientific use of aggregated capital instead of the individual resources of the ordinary farmer, may be depended upon to direct the forces of Nature to such an abundant increase of productivity as to meet all demands for ages to come.

If, however, such exploitation of the soil for the development of food supply is to be conducted in a thoroughly efficient manner it is essential that certain underlying principles be

taken into consideration, wholly apart from the detailed methods of execution of the work. Investigation of climatic conditions, such as can be conducted only by Government investigation extending over large areas of country, and properly co-ordinated over long periods of time, are essential. The extermination of injurious weeds, and especially the prevention of their seeding, through action of wind currents, in locations distant from their origin, is a basic feature of general agricultural development, and yet one which can be effectually controlled only by concerted action under strong administrative authority.

The general introduction of power machinery to replace animal power in agriculture, already progressing rapidly along individual lines, demands for its full development such combination of electric power stations and transmission systems as has been already effected in other departments of industry. When these and similar basic features have been fully advanced, the conduct of the exploitation of the soil at maximum efficiency may be depended upon to work itself out according to details which will appear in accordance with local conditions.

Another illustration of the important influence of a broadly efficient policy over one devoted to the improvement of details alone appears in the conduct of transatlantic navigation. It is well understood that the development of the propelling machinery of ocean liners represents one of the triumphs of mechanical engineering, and the fuel economy and general efficiency of the modern marine engine, whether of the turbine or the reciprocating type, is very high. At the same time the influence of fuel efficiency upon the total efficiency of the whole transport question is of minor importance compared with some other features which might be considered, and which should have been examined much earlier. The capital locked up in the great steamships which conduct the ocean-carrying trade is so great that its efficient use depends largely upon the continual activity of the boats themselves. This would indicate the advantage of gaining time in the ocean crossing if it were not for the fact that the operative cost of maintaining high speed largely neutralises the gain. If, however, the whole question of the expenditure of time were carefully investigated, and the opportunities of gaining time at other points than on the high sea were spread out for study and improvement, it might be found that the real opportunities for increased efficiency lie, not in the introduction of some more efficient propelling power, but in the installation of highly efficient handling machinery at the terminals for passengers, cargo and fuel, enabling a vessel to remain in port a much shorter time, permitting it to make a much greater number of profitable trips in the course of the year. Anyone who has been an observer of the time wasted in handling a large steamship at the pier, and compared it with the effort to gain a few hours in the ocean run, will realize where the opportunity for improved efficiency lies.

A similar study of the real problems of merchandise transport, conducted independently of any of the details of actual performance of the work, and examined wholly from the viewpoint of the thoughtful and broad-minded efficiency engineer, will reveal the fact that the real place for the development of efficient methods lies, not in the actual transport of the burden over material distances, but very largely in the distribution at the terminal points. It has been estimated that about 40 per cent. of the cost of food stuffs in New York City is due to the distribution costs, and yet the only attempt at the solution of this question yet offered appears to be the establishment of terminal depots of large capacity to which the purchasers should throng and receive their pur-

chases, to be carried away by themselves.

If, however, the questions involved in the distribution of materials brought into a great city were considered broadly, from the point of view of maximum efficiency, apart from the actual detailed methods of transport, the details might well be worked out by individuals to whom the broad view was lacking, but in whom the effective carrying out of requirements might be well found.

An illustration of the manner in which the attainment of a marked improvement in detailed efficiency may produce an almost insignificant effect upon the general efficiency of an entire installation will be seen in the limited possibility of increasing the efficiency of a power plant by the installation of more economical engines or boilers.

It has been shown that, in the operation of large central electrical generating stations, there is only 6 per cent. of the gross operating expenses required for fuel, while 50 per cent. is required for fixed charges, such as interest or dividends on investment, depreciation, taxes, insurance, etc., and 20 per cent. for general expenses, such as salaries of general officers, advertising, rentals, etc., only 30 per cent. of the gross expenses being actual operating costs, and 20 per cent. of this 30 per cent., or 6 per cent. of the gross, being the charge for fuel. Under such conditions any attempt to increase efficiency by introducing some improved type of motor, of lower fuel consumption, would make a gain of only 3 per cent. if the new machines were twice as efficient as the older ones, leaving out of consideration all questions of the costs and losses in making the change. Obviously, the true method of increasing the efficiency of such a plant lies in the reduction of wastes in the fundamental elements which make up the larger items of gross expenditure.

It has been felt by many that the great field for the development of more efficient methods of conducting the work of the world must necessarily lie in the better utilization of human labour, and much of the study which has hitherto been made for the development of efficiency has been devoted wholly to the actual physical work of the mechanic. This, too, is a department of study which demands, almost more than any other, a broad examination of basic principles before any very general progress can be made. No work, however effective in improving the efficiency of any special manual operation, can be of enduring value when the operation itself is of passing value and practically certain to be wholly abandoned very soon. The real study and effort should be devoted to the elimination of such work as is in itself of an inefficient character, without any attempt to improve its conduct, and to discover, so far as practicable, just what must remain to be done by men which cannot be performed more efficiently by manufactured power.

It may be said that this will work a great hardship to the ordinary man who now finds occupation in work of a simple character, and who may not be capable of performing operations requiring a higher degree of mental ability. This has been true of every development in times past, and it must continue to be so in all attempts to improve efficiency. A movement which increases the efficiency of the operation without developing the efficiency of the human race, considered as a whole, can hardly be considered broadly as being efficient at all. The lower grade man must himself be brought up to a higher grade by the very nature of the work he is to perform. Making the operator a part of the semi-automatic machine which he serves is not increasing his human efficiency, and the operation has been only half done which demands such service of workmen. The great, if not the greatest, underlying problem in the whole efficiency movement is the reduction,

if not the entire removal, of any requirement for men to perform work which does not involve the exercise of their mental capacities, since it has been amply demonstrated that man, considered from a mechanical point of view, is necessarily an inefficient means of accomplishing merely mechanical operations.

When the applications of manufactured power have reached their full efficiency, the benefits to the human race should be such as to preclude altogether the use of human effort for any purely laborious undertakings.

This question of the human machine, broadly considered, forms in itself an excellent example of the desirability of taking into account the fundamental underlying principles which govern efficiency. Attempts have been made to consider a man as a machine for the conversion of latent energy into the active or kinetic form, and computations have been made of the efficiency of man considered in connection with the oxidation of food upon a basis comparable with the combustion in an inorganic heat motor. It is very probable that such a comparison is altogether misleading, since there are forces about us acting upon the human organism to increase its efficiency which are not derived from the combustion of fuel or the oxidation of food. In many cases the efficiency of a man depends largely upon the stimulus derived from the example of successful and inspiring leadership, a fact which has long been understood and appreciated in military matters, but which has often been overlooked in the industrial warfare. The influence of healthful and cheerful surroundings upon the efficiency of workmen is beginning to be understood, and this is an element which is especially distinctive as separating the human machine from the inanimate apparatus. Broadly, it must be understood that maximum efficiency can be obtained from men only when they take a living, personal interest in the work which they they are doing, just as the members of a ball team must be stimulated by the desire to win, rather than by the direct pecuniary return which they are to receive. This is especially true for the higher kinds of work, in which the mental effort exceeds the physical labour, so that everything which tends to eliminate the more mechanical element and develop the mind at work enables the introduction of the stimulus of interest.

In the field of education there is especial necessity for the study of fundamental principles if maximum efficiency is to be attained, and it is here that abundant opportunity for thoughtful consideration may be found. Here, if anywhere, the stimulus of interest in the work is absolutely essential if any really valuable advance is to be made. Attention has often been directed to the facility with which boys of ordinary intellect will acquire knowledge which relates to things in which they are interested, and the computations which they will readily make in matters relating to games and various forms of sport show clearly that a fundamental element in education lies in the awakening of interest in the subject to such an extent as to remove entirely all idea of drudgery and introduce the same relations as exist in any game or other mental diversion. The eagerness with which an ordinary reader will follow the intricacies of a modern detective story, and the completeness with which the details are remembered after but a single reading, indicate lines along which the "fairy tales of science and the long result of time" might well be so deeply indented into the mind of the student as to be retained almost unconsciously.

Already the educational possibilities included in the use of the moving picture film for impressing upon the mind those things which until now have been taught only by the medium of a dreary succession of words, have been suggested, and in

the domain of zoology, at least, some remarkable results have been attained.

These, however, are details, the usefulness of which will appear as applications are made. The principal thing to be considered in any form of education, so far as improvement in efficiency is concerned, lies in the creation of an abiding interest in the subjects to be taught, and in the provision of opportunity for the satisfaction of that interest only by the attainment of the knowledge desired.

In this connection the subject of the education of mechanics may be mentioned, at least so far as the basic question of interest appears. Under the old plan of apprenticeship it was assumed that a period of seven years was required for the acquirement of an ordinary trade, and this at a time when workshop methods were far simpler and less highly organized than at present. It is well understood that much of this time was wasted, although opportunities of observation and for the reception of those hard knocks which are sometimes a valuable element in training were amply afforded. It has been lamented by many that this old apprenticeship system has fallen into decay, but from the point of view of efficiency it might seem to be a thing from which we are well freed. The facility with which a good working knowledge of a mechanical operation may be obtained, when opportunity and interest are involved, will be seen in the single example of the development of the use of the automobile. It will be conceded that the skillful operation of a high-class motor car includes as much ability as that demanded by a modern machine tool, considered both from the point of manual skill and from the requirements of swift judgment and perception; and yet, within a very short time of the practical introduction of the automobile, there were found plenty of young men who, in a few months' time had acquired a high degree of skill as chauffeurs. If this work had been of a dull, uninteresting kind, lacking in attraction and hedged about with mediæval precedents, it is evident that its acquirement, along old methods, would have been slow, uncertain, and unsatisfactory. As it is, we have an example of the ease and readiness with which a fairly intricate mechanical occupation may be quickly and effectively learned by men who would have found the antiquated methods of teaching unbearable and useless.

We see, in all that has been said, that the work of the development of efficiency in such varied occupations as those of manufacturing, of agriculture, of municipal congestion, of transport, of education, and of the utilization of labour depends broadly upon a proper view of the fundamental principles of the elimination of waste, whether of power, material, time, or thought, and if the work of developing efficiency is to succeed it must itself be conducted along the true lines of efficiency, and rest upon sure and simple foundations of basic value.

THE OPERATION AND TESTING OF POLYPHASE SYNCHRONOUS MOTORS

By J. W. Rogers

AS is well known, a polyphase synchronous motor is simply a polyphase generator reversed, and the conditions which exist in such a motor are (*a*) a field excited by a direct current, and therefore having polarity, (*b*) an armature supplied with alternating currents which at once indicates that the direction of rotation is variable. If, however, the machine could be run up to such a speed by mechanical means that the position of the armature with respect to the field would be such that a fixed polarity in space would result, there would be a torque in one direction, and therefore continuous rotation. To obtain this result the armature should rotate half a turn during the time occupied by one alternation of a full turn for every complete cycle of current. It follows, therefore, that the armature must generate a counter electromotive force of the same frequency as that of the impressed voltage, and under this condition the motor would operate in synchronism with the alternating current supply.

A synchronous motor will develop no driving torque until it runs at its synchronous speed, which is given by $\frac{\text{Frequency} \times 120}{\text{number of poles}}$. In the case of a single-phase motor, it is necessary to run it up to speed by external means before connecting it to the supply circuit, and should the speed fall below its synchronous value the motor would come to rest.

As already stated, for such a motor to develop a driving torque, it is necessary that the frequency of the supply current is the same as that of the counter E. M. F., generated in its armature, the value of its frequency being given by

$$\frac{\text{R. P. M.} \times \text{number of poles}}{120}.$$

When the frequency of the supply current is at its correct value, the direction of the current in any particular armature conductor at any instant will be reversed as that conductor passes from a field of opposite polarity, that is to say, if the machine is to exert a constant driving torque, the reversal of the current in each conductor must take place at the same time as that conductor is moving from one pole to the next.

As a synchronous motor is only capable of exerting a driving torque at one definite speed, which is quite independent of its field strength and supply voltage, the relation between the mechanical load on the motor and its electrical input corresponding to the load does not depend upon the ratio of the supply voltage to the counter E. M. F. of the motor, as is the case with a direct current machine, but is governed by the phase relation which exists between them.

A three-phase motor is self-starting at no load, due to the reaction which takes place between the rotating field generated by the armature currents and the field poles, but the field must not be excited, as the resultant flux would destroy the rotating field; it is also of vital importance to open the field connections in several places to prevent damage caused by the generation of high induced E. M. F.'s in the windings.

When considering the operating characteristics of a synchronous mo-

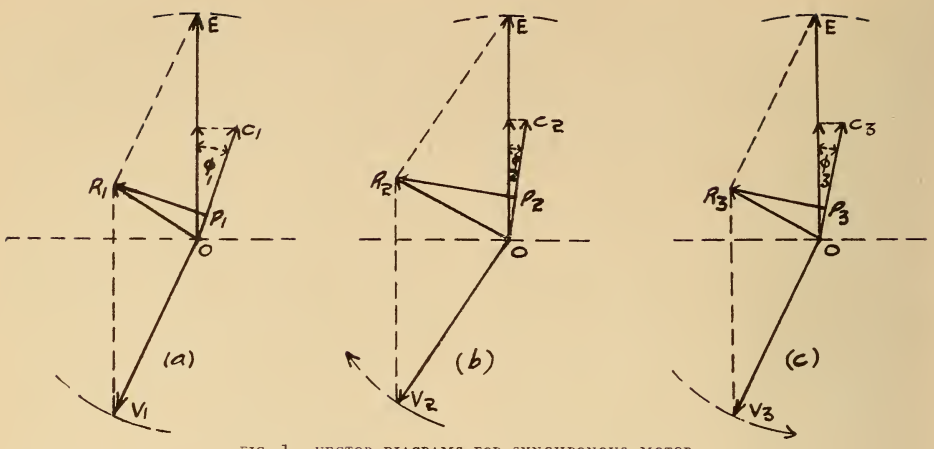


FIG. 1.—VECTOR DIAGRAMS FOR SYNCHRONOUS MOTOR

tor, it is necessary to take into account (1) impressed E. M. F., (2) counter E. M. F., (3) the resultant of these two E. M. F.'s, and (4) armature current and impedance, the adjustment of the armature current required by a change in the load on the motor being due to the change in magnitude of the resultant of the counter and impressed E. M. F.'s. As the motor speed remains constant at all loads it has no effect on the counter E. M. F., the change in the armature current at different loads being caused by an alteration in the phase difference between it and the impressed E. M. F., which alters the value of the resultant E. M. F.

The operation of a synchronous motor may be graphically represented by the vector diagrams in Fig. 1, which show the relation between the current and E. M. F. with a given excitation and constant impressed E. M. F. (*a*) at no load, (*b*) for an increasing load, and (*c*) for a decreasing load. With reference to the diagram (*a*) let *O E* represent the voltage applied to the motor terminals, and *O V* its counter E. M. F. at no load, then the resultant of these two E. M. F.'s, *O* R_1, represents the voltage available for overcoming the armature impedance.

The vector *O* R_1 is also the resultant of the resistance and reactance drops in the armature, these two quantities being represented by *O* P_1 and P_1 R_1, respectively, the angle ϕ_1 being such that

$$\tan \phi_1 = \frac{\text{armature reactance}}{\text{armature resistance}}.$$

The armature current which is given by $\frac{\text{resultant E. M. F.}}{\text{impedance}}$ is represented by the vector *O C*, being in phase with the resistance drop *O* P_1, and the angle of lag between the armature current and impressed voltage is ϕ_1, this diagram representing the current and E. M. F. relations of the motors when running on light load. When an increase in the load takes place, the vector representing the counter E. M. F., which remains constant at all loads, swings backwards in a clockwise direction, taking up the position *O* V_2 in diagram (*b*), thus working itself more out of phase with the impressed voltage *O E*.

The resultant electromotive force, *O* R_2, will now be increased sufficiently to allow of an increase in the armature current *O* C_2 required by the increased load. The angle of lag between the current and E. M. F. is now ϕ_2, and a reference to the diagram shows that, as the load increases, these two quantities are brought more nearly into phase, that is to say, an increase of load on a

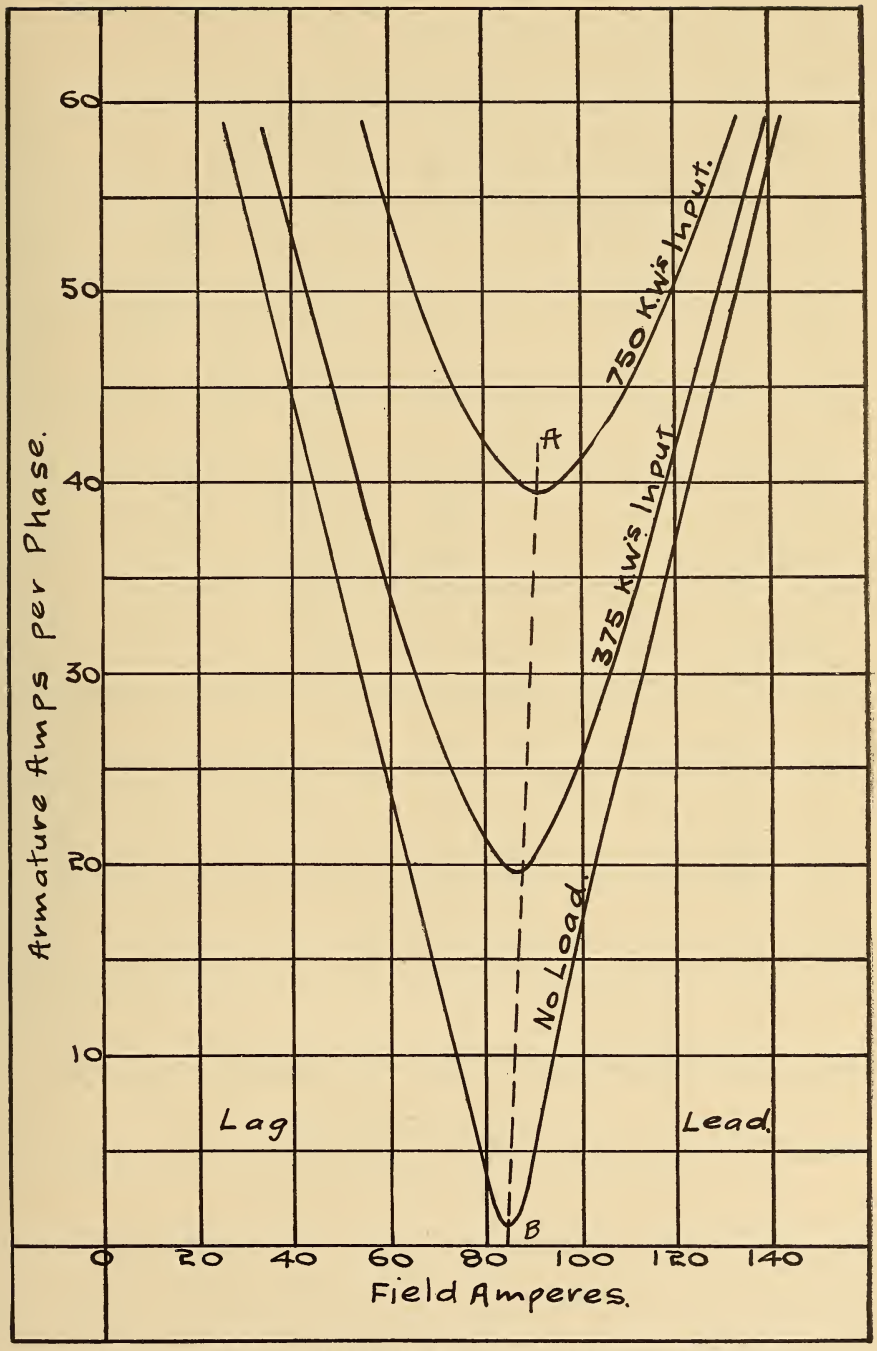


FIG. 2.—CURVES FOR A THREE-PHASE MOTOR, 1,000 HORSE-POWER, 11,000 VOLTS

synchronous motor increases its power factor to a certain extent without any adjustments of its excitation.

When the load on the motor decreases, the counter E. M. F. vector moves forward in a counter clockwise direction to position $O\ V_3$ in

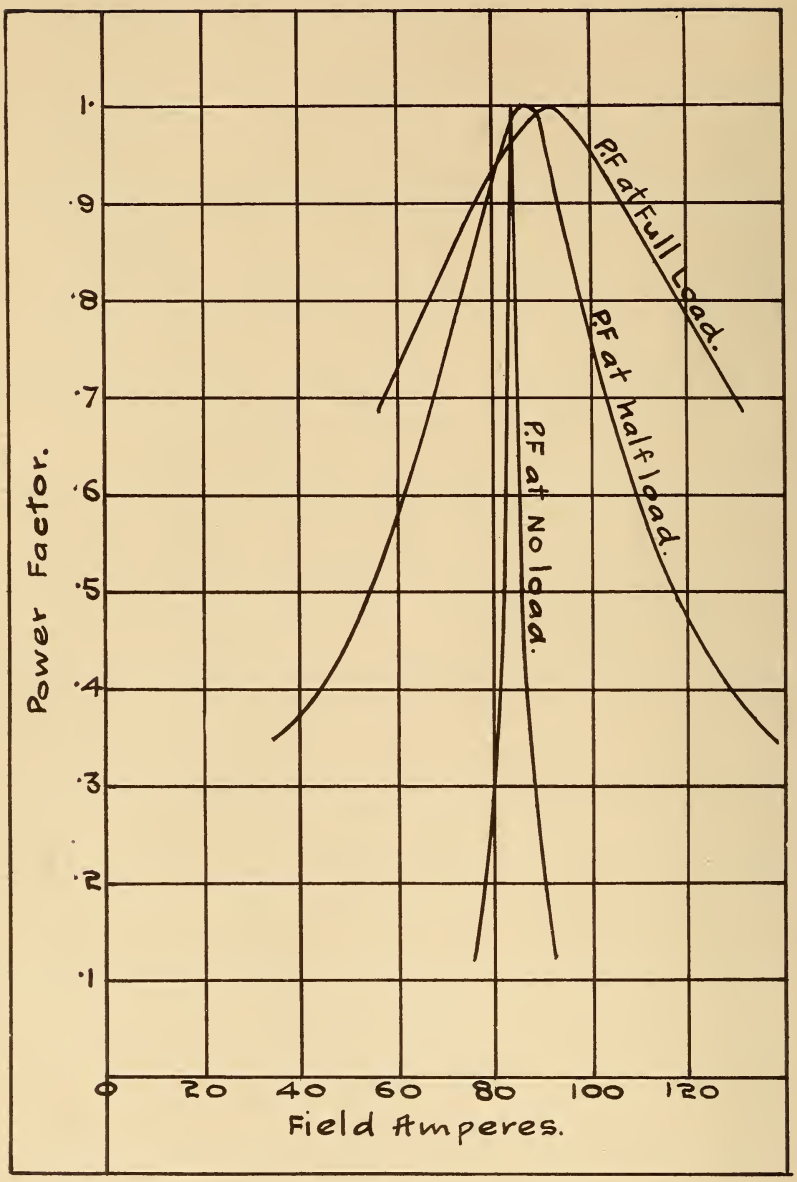


FIG. 3.—POWER FACTOR CURVES AT VARIOUS LOADS

diagram (*c*), thus gradually gaining in phase on *O E*. The resultant E. M. F. represented by *O* R_3 will now be reduced, the armature current *O* C_3 being decreased in proportion.

This balance between the impressed voltage and counter E. M. F. which is upset at every change in the load, is really maintained by armature reaction, the phase displacement between the armature current and counter E. M. F. being varied to enable the effect of the former to magnetize or demagnetize the field as required by the load.

When the load on a synchronous motor increases there is a momentary

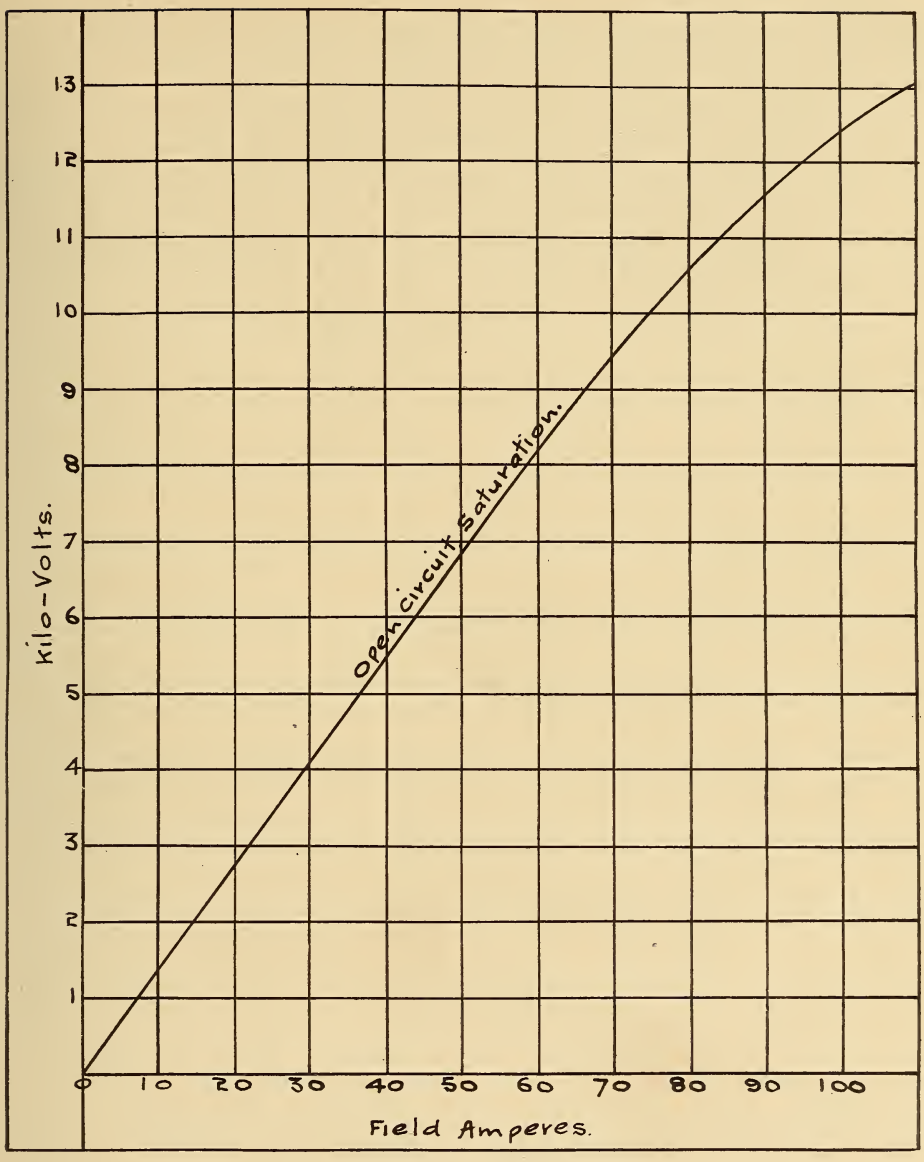


FIG. 4.—OPEN CIRCUIT SATURATION CURVE

drop in its speed, and this causes the armature to take up a new position, which alters the phase relation between the counter and impressed E. M. F.'s, so that the former offers less opposition to the latter, consequently the armature current will be proportionately increased. A decrease in load causes a reversed effect, so that the armature current automatically adjusts itself as regards its magnitude and phase relation to the value required by any particular load on the motor, and when this is the case the motor is considered to be running under stable conditions, so far as its operating characteristics are concerned.

As regards the excitation of synchronous motors, it is a well-known

fact that it is possible to run them at various values of power factor by altering the field strength, and this question may be considered as follows: When the excitation on a motor is such that the impressed voltage $= \sqrt{(\text{Counter E. M. F.}^2 + \text{C. R. drop}^2 + \text{reactive drop}^2)}$, the armature current will be exactly in phase with it, the power factor will be practically unity, and the current input to the motor will be a minimum. Any further increase in the excitation above this point will give rise to a leading current, which will cause the current input for any particular load to increase.

It follows, therefore, that every load has its corresponding value of excitation which enables the motor to work with minimum armature current. This variation of the armature current with the exciting current is one of the most important characteristics of the synchronous motor, and the curve representing such variation is, owing to its shape, known as a V curve. The exciting current required to give unity power factor at any particular load may either be found by trial or calculated from the no load saturation and short circuit curves taken from the machine when working as a synchronous generator, in the following manner:

First run the machine as a generator at its synchronous speed with an exciting current to give normal voltage, and calculate the armature C. R. drop at any given load. Next, find the exciting current C_1 required to give the sum of the normal volts and C. R. drop, on open circuit, also the exciting current C_2 required to give that particular value of load current in the armature with its windings short-circuited, then the exciting current required by the machine when working as a synchronous motor, to give unity power factor $= \sqrt{C_1^2 = C_2^2}$.

As is well known, the possibility of working a synchronous motor with a leading current renders this machine most suitable for improving the power factor of an alternating current system, and the manner in which the exciting current of such a motor alters the power factor of the generator supplying it with power may be considered as follows:

The lagging component of the armature current has a demagnetizing effect on the field, therefore the stronger the field the greater the lag relative to the counter E. M. F. of the motor, or lead relative to the E. M. F. of the generator, and a decrease in the field strength of the motor requires the leading component of the current to supply the difference caused by a lagging current, to enable the resultant exciting strength to be held at a constant value.

Having considered the operating characteristics of synchronous motors, a brief description of the shop tests generally carried out on these machines may prove of interest. These tests are chiefly experimental and consist of (1) resistance, (2) open and short circuit characteristics, (3) iron loss, saturation and friction, (4) efficiency, (5) regulation and V curves. With the exception of the latter these tests are similar to those made on alternators, which are doubtless well known to readers of this journal, so that it will only be necessary to refer to the regulation and V characteristics. The data for the regulation and V curves are obtained by belting the synchronous motor to a direct current generator of sufficient capacity to transmit the full load of the former when run on a resistance rack. This test is started by running the synchronous motor up to speed by means of the direct current machine, which is connected to a suitable supply and run as a motor for this purpose.

After the synchronous motor has been synchronized and connected to the alternating current supply, the direct current machine is disconnected from the supply circuit and connected as a generator to the rack resistance. The synchronous motor is then run on no load, half load, and

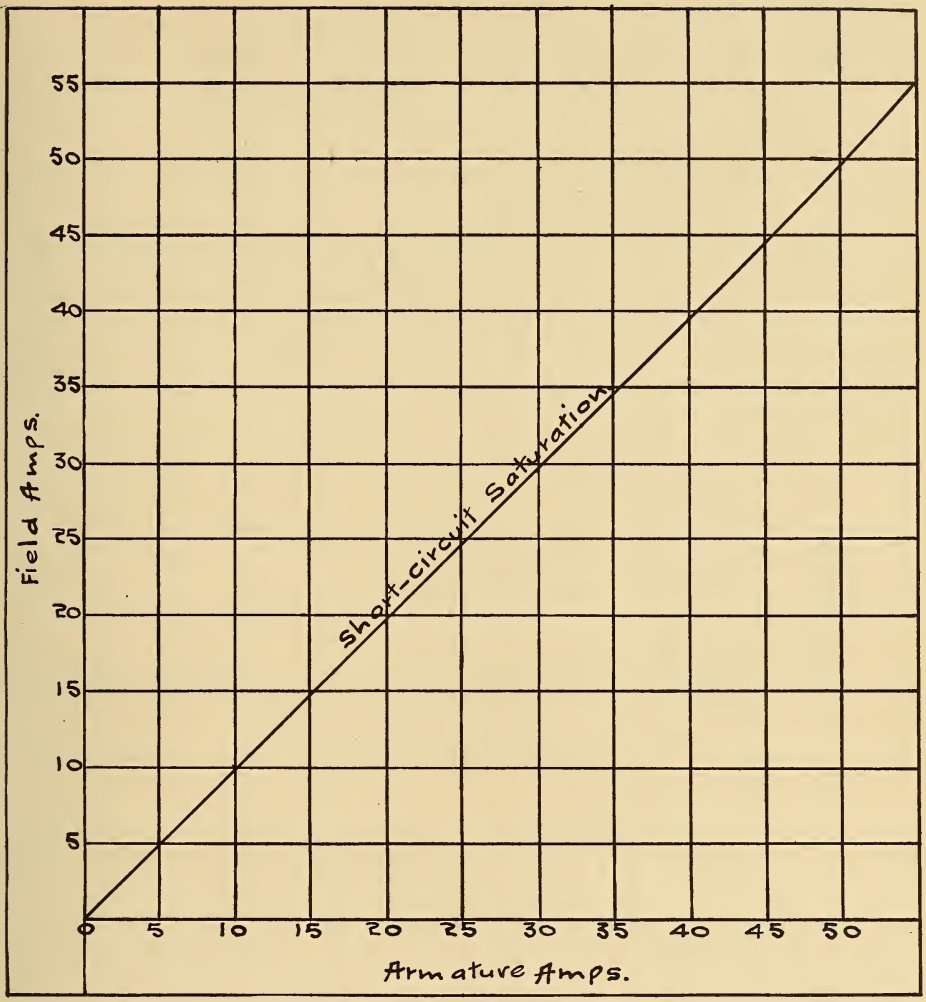


FIG. 5.—SHORT-CIRCUIT SATURATION CURVE

full load, at different exciting currents, taking readings of armature and field amperes, the former being plotted as ordinates and the latter as abscissæ.

The series of V curves shown in Fig. 2 were obtained from a 1,000 horse-power, 11,000-volt three-phase motor, and they indicate that the armature current varies to a greater extent, also that the curve is more V-shaped at no load than when the motor is loaded, also that the variations in armature current for any particular values of exciting decrease as the load increases.

When the power factor of the motor is unity, the apparent watts will be equal to the true watts input, and as the terminal voltage is held constant, the value of the armature current may be taken as a measure of the power factor, so that it is possible to calculate the power factor from the data given by the V curves, and this has been done for different loads on the motor in the following manner:

The full load rating of the motor is 1,000 horse-power, which corresponds to 750 kilo-volt amperes.

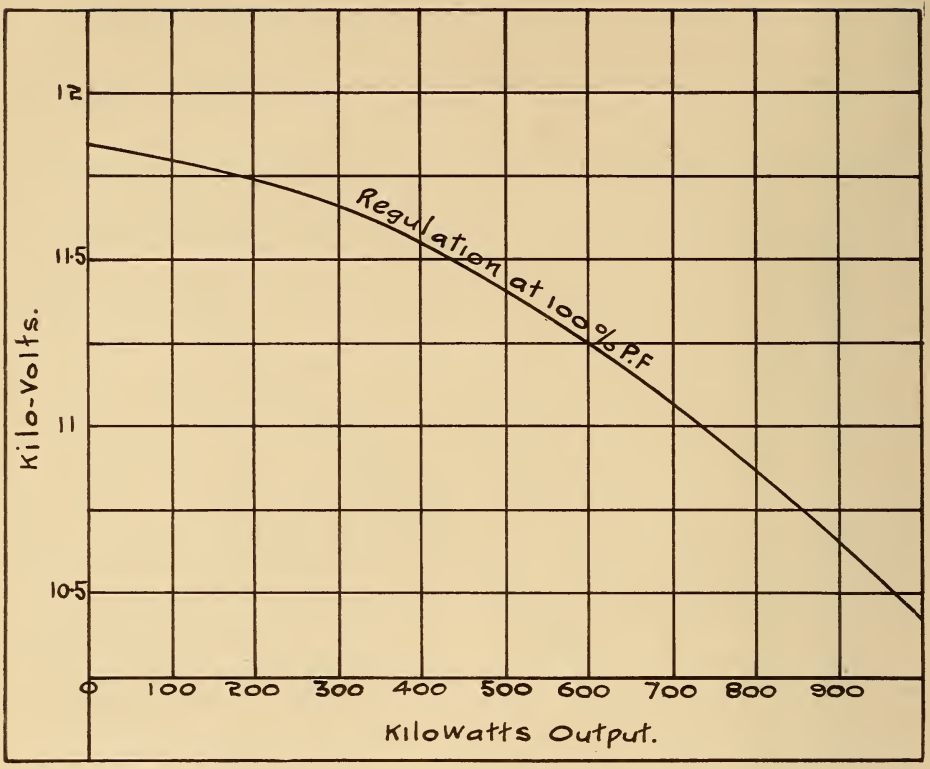


FIG. 6.— REGULATION CURVE

$$\text{Full load current} = \frac{750 \times 1{,}000}{11{,}000 \times 3} =$$

39.4 amperes per phase, and a reference to the full load V curve shows that this agrees with the current input at unity power factor; that is to say, the ratio

$$\frac{\text{true input current}}{\text{actual input current}} = \frac{39.4}{39.4} = 1,$$

and this corresponds to an exciting current of 92 amperes.

Taking another point on the curve, viz., 45 amperes, its corresponding

$$\text{power factor} = \frac{39.4}{45} = .875,$$

the other points being found in a similar manner. The results of these calculations at full, half and no load are given in Tables I, II and III, respectively, and are also shown by the curves in Fig. 3. The curve representing the power factor at no load shows very plainly how widely it varies for different values of the exciting current when the motor is running light. The open and short circuit saturation curves for this motor are shown in Figs. 4 and 5, respectively.

TABLE I.

Power Factor at Full Load.	Exciting Current. Armature Current, Lagging. Amperes,	Armature Current, Leading. Current in Phase.
1.	92	...
.985	88	96
.9275	80	104
.875	74	110
.788	66	120
.723	60	127
.686	57	132

TABLE II.

Power Factor at Half Load.	Exciting Current. Armature Current, Lagging. Amperes,	Armature Current, Leading. Current in Phase.
1.	86	...
.985	84	90
.916	80	93
.7875	73	99
.5725	60	112
.4925	54	118.5
.3720	40	134
.343	35	138.5

TABLE III.

Power Factor at No Load.	Exciting Current. Armature Current, Lagging. Amperes, Current in Phase.	Armature Current, Leading.
1.	84	.....
.768	83	85.5
.5	82	86.5
.28	80	88.5
.125	76	92.5

The regulation curve of this machine when working as a generator at unity power factor and a constant exciting current is shown in Fig. 6, and the curve in Fig. 7 represents its efficiency as a motor, and calculated from the losses but neglecting the loss due to friction and windage.

With further reference to the V curve of a synchronous machine it follows from the preceding remarks that the shape may be taken as an indication of its performance.

For instance, a broad curve indicates that the motor has a small overload capacity, but will require but small alterations in its exciting current for varying loads.

On the other hand, a steep curve indicates good regulating qualities, also that the machine would only work satisfactorily when its exciting current is correctly adjusted, which is necessary to insure a fair overload

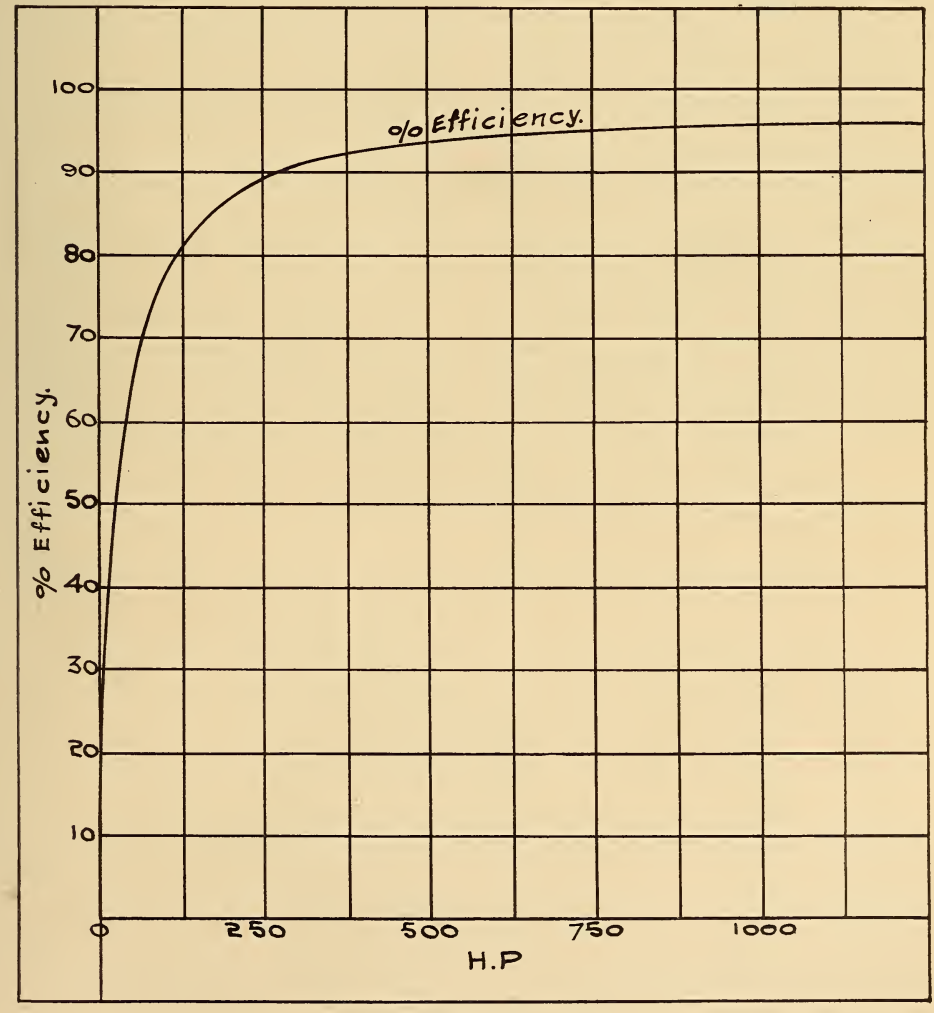


FIG. 7.—EFFICIENCY CURVE

capacity and suitable characteristics for parallel operation. It will be seen that when the motor is loaded its V curve alters in position and shape, which is due to the effects of armature reaction and leakage. The smaller the inclination of the axial line *A B* from the vertical the smaller the pressure drop, and increase of excitation necessary from no load to full load, to enable the motor to work at unity power factor.

When the armature current is at its minimum value for a given load, the difference between the counter E. M. F. of the motor and the impressed voltage is due to the armature impedance and phase displacement between current and voltage.

When a synchronous motor is operating at constant load with constant exciting current, the phase displacement between the impressed voltage and counter E. M. F. is still continually changing, due to the variations in the angular velocity of the generators, and even if the impressed voltage is held constant a small decrease or increase in exciting current will result in a rapid increase in the armature current taken by the motor.

The value of the C. E. M. F. for any particular load and exciting current represents the resultant of it and the impressed voltage, which is really the impedance voltage of the armature, and if the excitation is increased above that value corresponding to a maximum power factor, the impressed voltage must lag behind the current to maintain a balance between the relations here mentioned.

If the exciting current is less than that required to give a maximum power factor at any particular load, the impressed voltage would lead the armature current for the same reasons.

In conclusion, it should be stated that it is not possible to obtain a power factor of exactly unity by adjusting the exciting current, as the bottom of the V curve does not indicate that the armature current and impressed voltage are in phase.

Although they are very nearly in phase with each other, there is always a slight lag between them, due to the difference in the E. M. F. curves of the motor and generator.

When large synchronous motors are operating at full load it is generally possible to obtain a maximum power factor at 98 per cent. with an exciting current corresponding to a minimum current in the armature.

THE SOURCES OF THE WORLD'S COPPER SUPPLIES IN 1912, AND THE INFLUENCE OF OUTPUT UPON PRICE

By John B. C. Kershaw, F. S. S.

INTRODUCTION

THE fact that 1912 has witnessed a rapid rise in the market price of copper to over £70 per ton, after a long period of low values, should render the subject of the present article of exceptional interest to readers of CASSIER'S MAGAZINE. In spite of the increasing extent to which aluminum, tin, lead and zinc, and the alloys of these metals, are being used in the arts and industries, copper remains, after iron and steel, the most useful of the metals available for general use, and the demand for the red metal, so far from diminishing, is expanding at a rapid and even alarming rate.

Within thirteen years the world's consumption of this metal has more than doubled, increasing from 429,626 tons in 1898, to 873,460 tons in 1911. The advent of aluminum, so far from causing any diminution of the demand for copper, seems only to have stimulated it, and with the large projects of railway electrification ahead, in Great Britain and in America, it is quite probable that in 1915, or before that date, the world's consumption of copper will amount to the stupendous total of 1,000,000 tons per annum, with a value of £60,000,000 to £80,000,000.

These figures show the enormous importance of copper to the successful conduct of the manufacturing industries of the leading industrial countries, and indicate that an examination of the sources of the world's copper supplies should prove of interest and value to all engineers. The influence of output upon prices is also worthy of their close attention; for the difference between copper at £55 per ton and copper at its present price of £70 per ton, represents an additional cost of £13,500,000 per annum for the industries in which the metal is used.

In the following pages the author has made use of the figures contained in the annual and monthly statistical circulars, published by the well-known London firm of metal brokers, Messrs. H. R. Merton & Co., to trace the development of copper supplies from the twelve leading producing countries, during the past 15 years, and to indicate the variations in price that have occurred during the same period. In order to facilitate this study of the statistics of copper, all the figures given in the course of the article have been reduced to diagrammatic form, this method of presenting statistics covering a series of years being by far the most illuminating and instructive.

1. Growth of the World's Total Output of Copper, 1897-1911.

Table I and Diagram I give the figures showing the total copper supplies from all producing countries of the world for the fifteen years ending 1911.

TABLE I.—TOTAL WORLD'S OUTPUT, 1897–1911.

Year.	Output, Tons.	Increase or Decrease.
1897	399,730	26,400
1898	429,626	29,900
1899	472,244	42,600
1900	479,514	7,300
1901	516,628	37,100
1902	541,295	24,600
1903	574,775	33,500
1904	644,000	69,300
1905	682,125	38,100
1906	714,100	32,000
1907	713,965	(-,135)
1908	754,180	40,200
1909	839,425	85,300
1910	855,685	16,200
1911	873,460	17,800

The variations in production from year to year have been very irregular, ranging from an increase of 7,300 tons

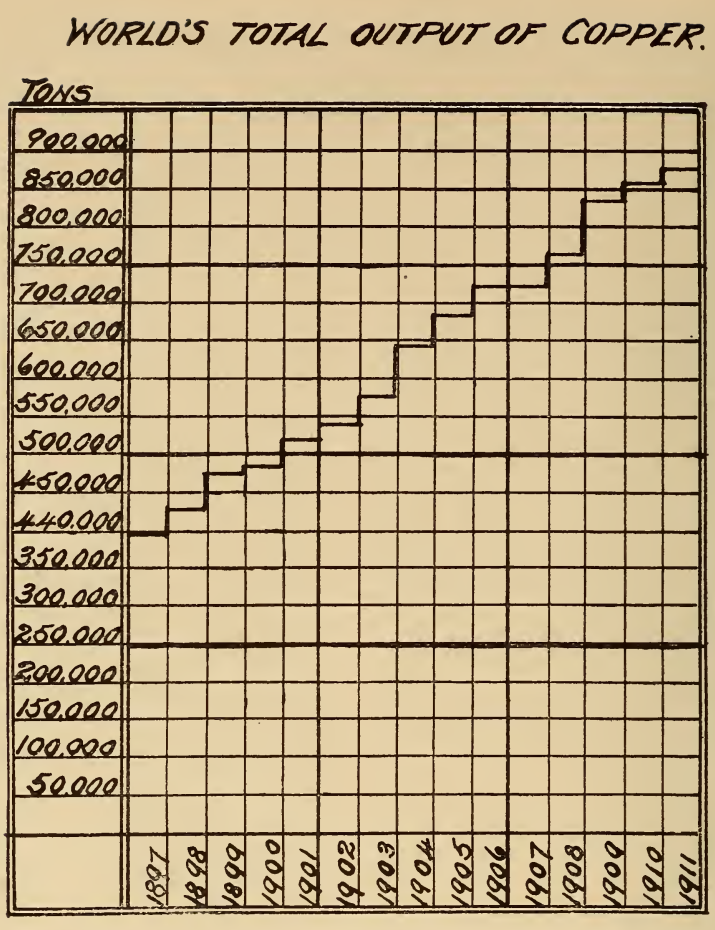


DIAGRAM I.—THE WORLD'S COPPER PRODUCTION

in 1900 to one of 85,300 tons in 1909, with a decrease of 135 tons in 1907. Taking the average rate of increase over the whole period, however, we obtain a figure of 31,600 tons per annum, which may be taken to represent the normal increase, when no outside influences are at work to increase or diminish the output. The wide variation between this normal rate of increase of 31,600 tons per annum, and those shown in the above table, indicates that in particular years the influence of prices or stocks had made itself felt. The diminished rate of increase during the past two years, for example, shows that an attempt has been made (with some success) to reduce stocks and to bring about an improvement in the low level of prices which had been ruling since the collapse of 1908.

II. The Relationship between the World's Total Output of Copper and the Production of the Mines of the United States.

Table II and Diagram II show the relationship of the American production of copper to that of the remaining countries of the world. The percentage of the total output provided by the American mines has been increasing in recent years, in spite of the developments of copper mining in Japan, Australasia, Russia and South Africa, and as shown above has increased from 54 to 56 per cent. in the period under review, while that of the remaining

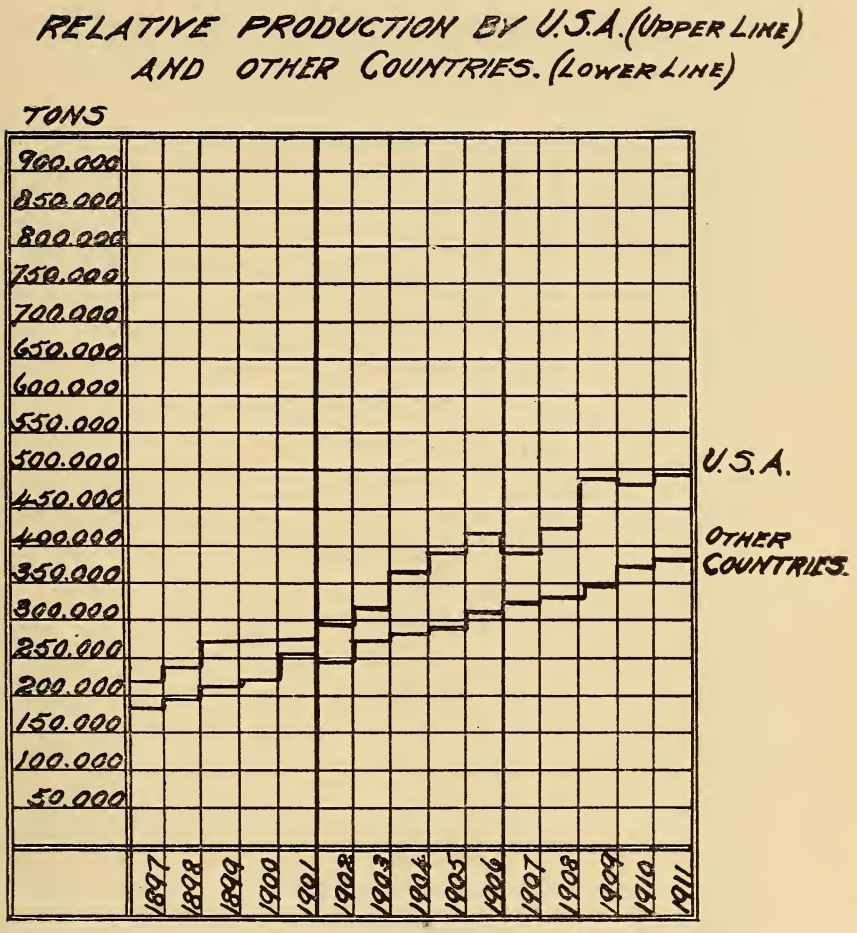


DIAGRAM II.—AMERICAN COPPER PRODUCTION

countries has shown a corresponding falling off. The chief center of the world's copper production and finance is still located in the United States, and this is one reason why it is so difficult to foretell the price movements for the metal for any length of time ahead.

TABLE II.—RELATIVE PRODUCTION OF COPPER BY THE MINES OF THE UNITED STATES AND THOSE OF OTHER COUNTRIES.

Year.	U. S. A. Mines. Tons.	Percentage.		Other Countries. Tons.	Percentage.	
1897	216,060	54		183,670	46	
1898	234,271	54	Average.	195,355	46	Average.
1899	262,206	55	54.5	210,038	45	45.5
1900	263,502	55		216,012	45	
1901	265,250	51		251,378	49	
1902	292,870	54		248,425	46	
1903	307,570	53	54.2	267,205	47	45.8
1904	365,050	56		278,950	44	
1905	389,120	57		293,005	45	
1906	409,650	57		304,450	43	
1907	392,520	55		321,445	45	
1908	423,300	56	56.2	330,880	44	43.8
1909	490,280	57		349,145	43	
1910	484,935	56		370,750	44	
1911	492,650	56		380,810	44	

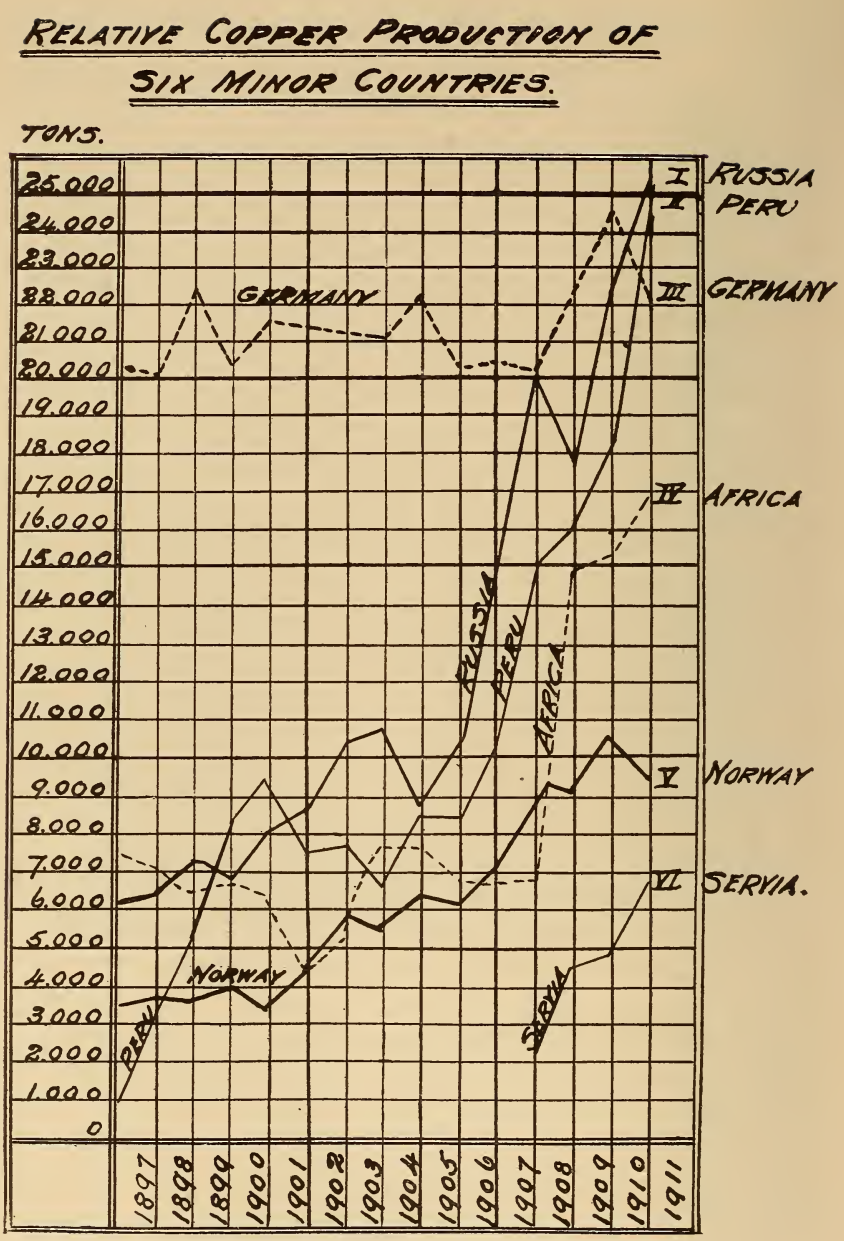


DIAGRAM III.—MINOR COPPER PRODUCING COUNTRIES

III. The Copper Output of the Twelve Leading Remaining Countries in the period 1897-1911.

The twelve leading copper producing countries, after exclusion of the United States, rank in the following order when judged by their output of the metal in 1911:

Japan, Mexico, Spain and Portugal, Australasia, Chili, Russia, Peru, Canada, Germany, Africa, Norway, Servia. Many of the above countries show great expansion of their copper mining industry in the period under review, Japan, Mexico, Australasia and Peru showing the most progress.

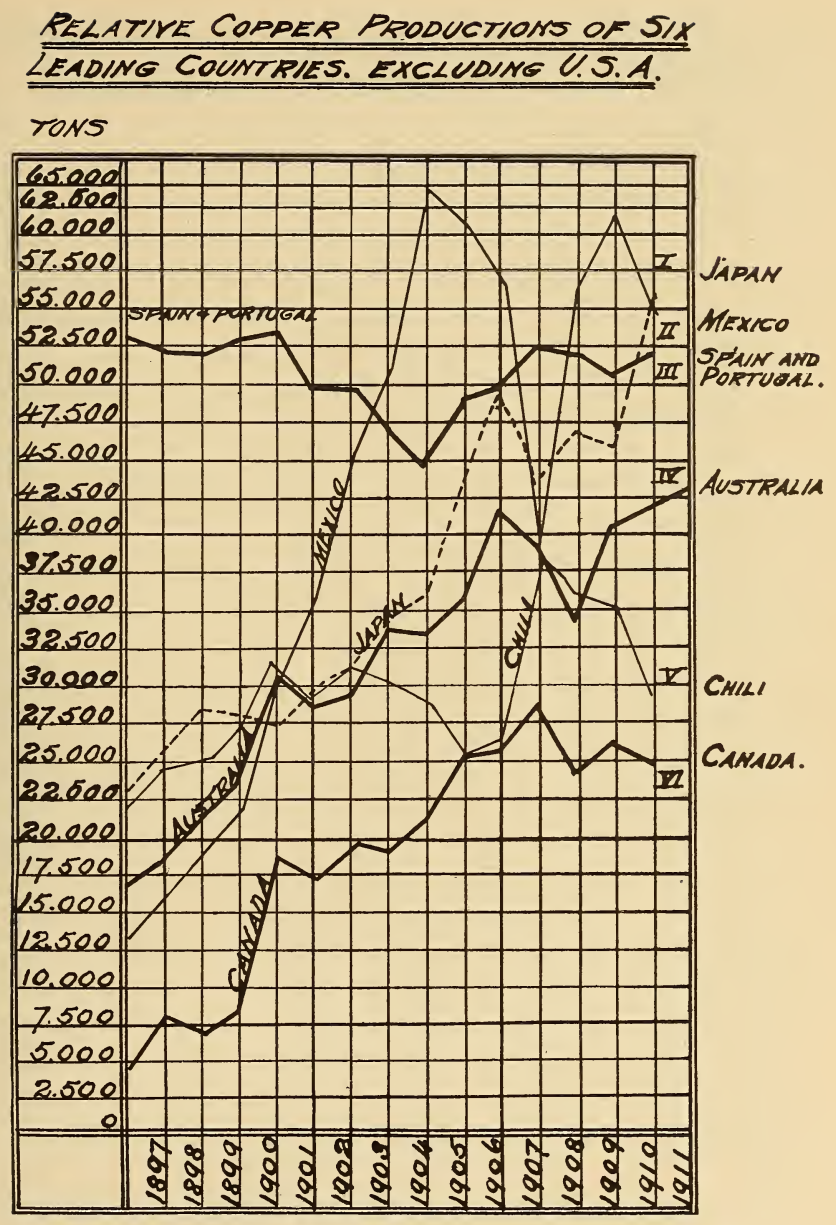


DIAGRAM IV.—MAJOR COPPER PRODUCING COUNTRIES OTHER THAN THE UNITED STATES

Mexico, which in 1897 produced only 13,370 tons, attained its maximum output in 1905, when a total of 64,440 tons was shipped.. Since that year the total has varied, according to the state of the copper market, and in 1911 only 54,030 tons were produced. The Mexican mines are controlled chiefly by New York financial interests, and in recent years a large number of old mines have been reopened and worked again.

Japan has shown steady progress as a copper producing country, and the

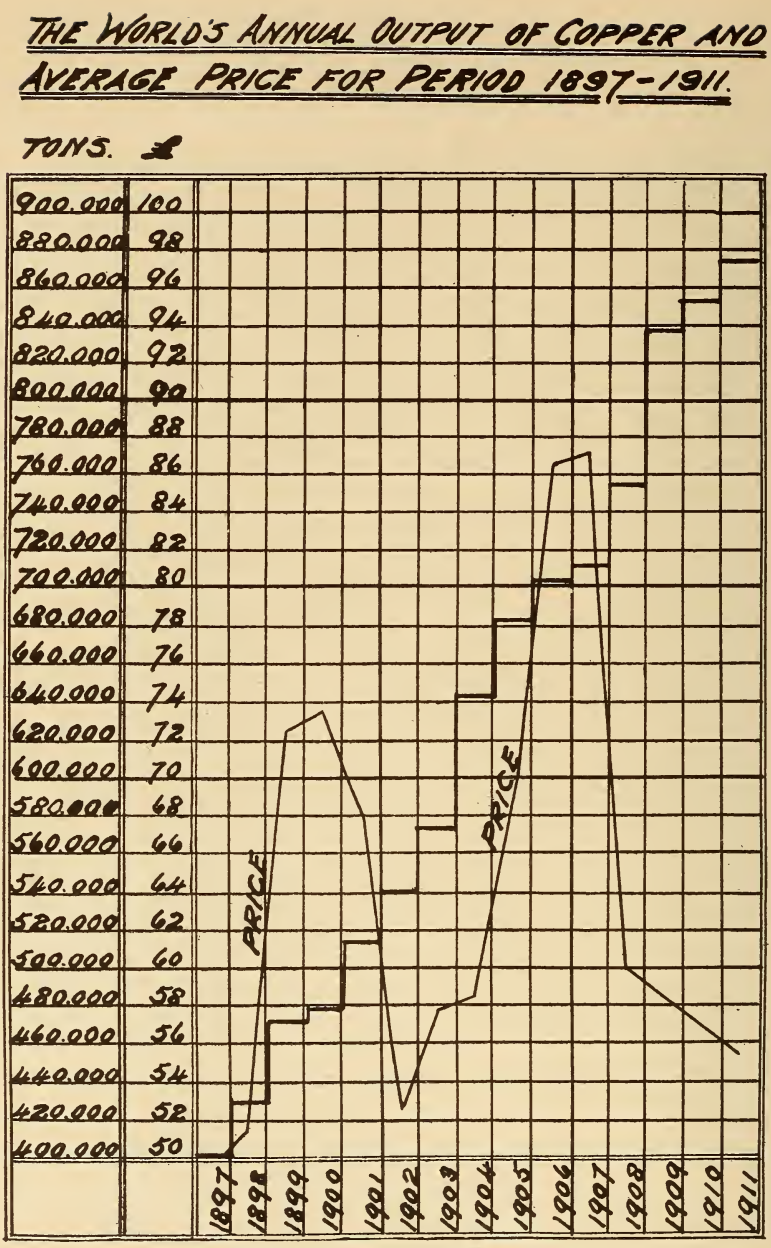


DIAGRAM V.—COPPER PRODUCTION AND PRICES

output has risen from 23,000 tons in 1897 to 55,000 tons in 1911. In the latter year Japan ranked second to the United States in the list of producing countries.

Australasia and Canada. The copper mining and smelting industries in these two countries have also shown notable expansion during the last fifteen years, the Australasian output having increased from 7,000 tons to 41,800 tons in 1911, and that of Canada from 6,000 tons to 25,000 tons in the same period.

Canada attained its maximum output in 1908, however, when 28,570

tons were produced, and it remains to be seen whether the new high level of prices for copper will lead to this output being exceeded in 1912.

Peru has shown remarkable development as a copper producing country, the increase being from 1,000 tons in 1897 to 25,445 tons in 1911. It is quite possible that this rate of progress will be maintained for the next few years, and that Peru may equal Mexico in its output of the red metal.

Russia is another country in which copper mining has developed very rapidly during the last decade, the increase in this case being from 6,740 tons in 1900 to 25,570 tons in 1911. Here again there are possibilities of a much greater expansion of the mining and smelting industry.

Africa has advanced her output from 6,880 tons in 1908 to 17,000 tons in 1911, and when the much-talked-of Tanjanyka mines begin to add their quota of copper to the export of the metal the African continent may be expected to add greatly to the world's supplies of copper.

Germany, Spain and Portugal, and Chili are the only countries which have not increased materially their output of copper during the past fifteen years. In the case of the two former countries, this non-expansion is due to the settled policy of the companies controlling the mines to work them regularly and to maintain a steady output, rather than to force production and exhaust the ore reserves at an earlier date.

Servia is a new addition to the ranks of copper producing countries, having only commenced to mine and smelt the metal in 1908.

Cuba is another country which commenced the industry in the same year and already in 1911 produced 4,415 tons of the metal.

Table III and Diagram III contain the detailed figures for the twelve countries named above.

IV. Variations in Price for the Period 1897-1911, and the Relationship between Output, Consumption, Stocks and Prices.

The figures showing the average price of standard copper for the period 1897-1911, are given in Table IV and Diagram IV. This table and diagram also show the corresponding fig-

TABLE III.—THE COPPER OUTPUT OF THE LEADING PRODUCING COUNTRIES (EXCLUDING UNITED STATES OF AMERICA) FOR THE PERIOD 1897–1911.

Year.	Mexico.	Spain and Portugal.	Japan.	Australasia.	Chili.	Canada.
1897	13,370	53,060	23,000	17,000	21,900	5,905
1898	16,435	52,375	25,175	18,000	24,850	8,040
1899	19,335	52,168	28,310	20,750	25,000	6,730
1900	22,050	52,872	27,840	23,020	25,700	8,500
1901	30,430	53,621	27,475	30,875	30,780	18,800
1902	35,785	49,790	29,775	28,640	28,930	17,485
1903	45,315	49,790	31,360	29,000	30,930	19,320
1904	50,945	47,035	34,850	34,160	30,100	19,185
1905	64,440	44,810	35,910	33,940	29,165	20,535
1906	60,625	49,320	42,740	36,250	25,745	25,460
1907	56,565	49,675	48,935	41,250	26,685	25,615
1908	39,990	52,585	43,000	39,500	38,315	28,570
1909	56,325	52,185	47,000	34,400	35,785	24,105
1910	61,515	50,255	46,000	40,315	35,235	25,715
1911	54,030	52,045	55,000	41,840	29,595	24,930

Year.	Russia.	Peru.	Germany.	Africa.	Norway.	Servia.
1897	6,025	1,000	20,145	7,440	3,450	.....
1898	6,260	3,040	20,085	7,110	3,616	.....
1899	7,210	5,165	23,460	6,490	3,610	.....
1900	6,740	8,220	20,410	6,720	3,935	.....
1901	8,000	9,520	21,720	6,400	3,375	.....
1902	8,675	7,580	21,605	4,450	4,565	.....
1903	10,320	7,800	21,205	5,230	5,915	.....
1904	10,700	8,755	21,045	7,775	5,415	.....
1905	8,700	8,625	22,160	7,740	6,305	.....
1906	10,490	8,505	20,340	6,980	6,120	.....
1907	15,000	10,575	20,490	6,800	7,010	.....
1908	20,085	15,000	20,200	6,880	9,190	2,140
1909	17,750	16,000	22,455	14,945	9,080	4,480
1910	22,310	18,305	24,710	15,205	10,425	4,845
1911	25,570	25,445	22,010	16,980	9,420	6,885

ures for the total output of copper in each year of the fifteen covered. It has not been possible to correct the output of copper for the variations in

TABLE IV.—THE WORLD'S OUTPUT OF COPPER COMPARED WITH THE AVERAGE PRICE OF "STANDARD" METAL, FOR THE PERIOD 1897-1911.

Year.	Total Output.	Average Price per Ton.
1897	399,730	£49 10 0
1898	429,626	51 7 10
1899	472,244	72 10 6
1900	479,514	73 19 7
1901	516,628	67 17 3
1902	541,295	52 13 5
1903	574,775	57 18 8
1904	644,000	58 14 8
1905	682,125	69 2 6
1906	714,100	86 5 2
1907	713,965	87 1 8
1908	754,180	60 0 6
1909	839,425	58 17 3
1910	855,685	57 3 2
1911	873,460	55 16 2

stocks, and thus to make evident the relationship between consumption and price for the whole period, but a supplementary table and diagram (V)

TABLE V.—THE WORLD'S CONSUMPTION OF COPPER COMPARED WITH THE AVERAGE PRICE OF "STANDARD" METAL, IN 1909, 1910, 1911.

Year.	Stocks (in Tons) Increase or Decrease.	Estimated Consumption in Tons.	Average Price per Ton.
1909	+61,700	839,425	£58 17 3
1910	—34,100	855,685	57 3 2
1911	—41,000	873,460	55 16 2

give this information for the last three years. In 1909 the production exceeded the consumption by 61,700 tons, whereas in the years 1910-111 the position was reversed and consumption exceeded the output by 34,100 tons and 41,000 tons respectively. This excess of demand over production explains the recent rise in value.

The estimated world's consumption of copper during the twelve months ending Dec. 31, 1911, was 914,460 tons, an increase of 25,000 tons upon the previous year's consumption, and at this rate of progress the world's consumption of copper will reach 1,000,000 tons per annum about 1915.

The curve for the prices of copper in Diagram IV shows two short periods of high prices, followed by two longer periods of depression. The earlier boom was due to the formation of the Amalgamated Copper Company in the United States; the second one to the extremely active state of the engineering, shipbuilding and allied industries at a period when there was some slackening off in the rate of production.

It is not generally recognized that activity in the shipbuilding industry creates a great demand for copper, and, as pointed out by a writer in the *Times*: "If the man in the street or the speculator in copper-warrants were to make an exhaustive examination of a first-class high-speed ocean liner he would be amazed at the quantity of copper, plain or as brass, required about her engines, her auxiliary plant, her sanitary arrangements, her kitchens, her saloons, staterooms, and staircases, even her portholes, rails and scuppers."

How much copper has gone down to the bottom of the Atlantic with the ill-fated *Titanic* only the builders know, but it must amount in value to many hundreds of thousands of pounds.

The sudden upward trend of prices that has marked the last three months is well brought out by Table VI and Diagram VI, which show the variations in stocks and prices of standard copper at the end of each quarter for the past three years.

TABLE VI.—VARIATIONS IN STOCKS AND PRICES DURING THE PAST THREE YEARS

Quarter Ending	Stocks in America and Europe, (Excluding Holland and Germany), Tons.	Price.
Dec. 31st, 1908	110,667	£63 15 0
Mar. 31st, 1909	132,729	57 0 0
June 30th, 1909	136,512	58 17 6
Sept. 30th, 1909	161,483	59 7 6
Dec. 31st, 1909	172,310	61 15 0
Mar. 31st, 1910	166,711	57 17 6
June 30th, 1910	179,129	54 10 0
Sept. 30th, 1910	160,386	55 2 6
Dec. 31st, 1910	138,275	55 17 6
Mar. 31st, 1911	154,592	54 10 0
June 30th, 1911	140,455	57 0 0
Sept. 30th, 1911	130,239	55 0 0
Dec. 31st, 1911	97,218	62 15 0
Mar. 31st, 1912	78,018	68 10 0
April 15th, 1912	.....	70 7 6

From these figures we see that the stocks of copper reached their maximum in May and June, 1910, when they touched a level equal to one-fifth of a year's consumption, and that the price of the metal touched bottom, £54/10/0 per ton, about the same time. Since that date there has been

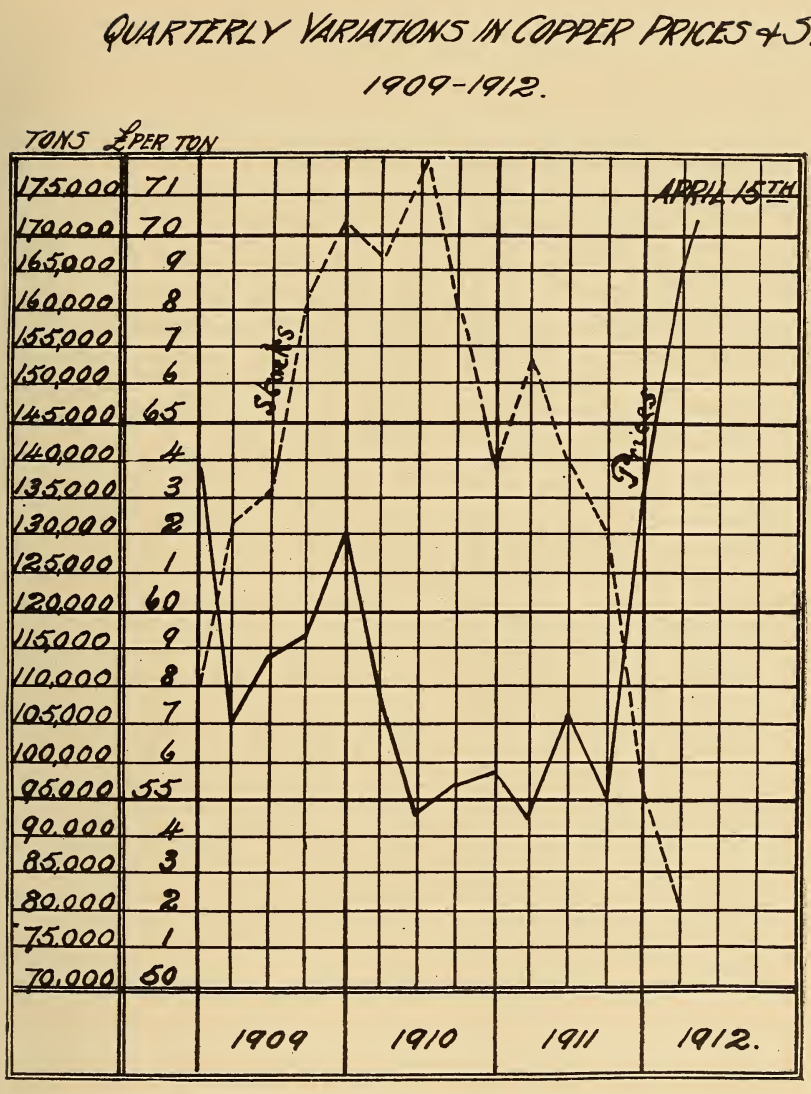


DIAGRAM VI.—VARIATIONS IN COPPER PRICES AND STOCKS

a rapid depletion of the stocks, accompanied by a slow but steady increase in value, culminating in the notable spurt of the last few weeks. Diagram VI shows the same figures in the form of a curve.

CONCLUSIONS

As shown above, the consumption of copper in 1911 exceeded the output of the metal by 41,000 tons, and the figures for 1912 when complete may quite possibly show a still larger consumption of the red metal and a further depletion of stocks in order to meet the steadily growing demand. Any further rise in price is, however, likely to cause a spurt in the production of the metal in Japan, Australasia,, Mexico and Peru, and possibly Africa, and though copper may quite possibly touch £80 per ton before the current year is ended, the writer considers it unlikely that the extraordinarily high level of prices attained in the winter months of 1906-1907 will again be reached.

SMOKE PREVENTION

By John S. Franklin

CAN smoke be prevented? The best answer to this question is the fact that many factories, mills, power plants, and the like are to-day being actively operated without the production of an appreciable amount of smoke. There are many others where the output of smoke is considerable. There can be no doubt that in the case of the great majority of plants where smoke is produced the reason is to be found in some defect of the arrangements. It will not be necessary to cite instances of smoke production. They abound on every hand. It may be permitted, however, to cite a case where smoke is actually prevented.

The New York City mill of the Hecker-Jones-Jewell Milling Company is one of the largest in the world, having a capacity of 10,000 barrels per day of 24 hours. The power plant includes a boiler equipment of six units, each having a rating of 350 horse-power. These boilers are the source of the power operating the machinery of the mill, which is in part driven by steam and in part by electricity; they are also the source of the heat and light used throughout the plant. With four boilers in ordinary operation at the beginning of cold weather, the coal consumption amounts to about 50 tons per day of 24 hours. The variety used is a good grade of bituminous coal—not a fancy coal. The chief engineer states that they have no smoke. Here, then, is a good typical case showing that smoke prevention is a real possibility.

Now, how is it possible to use bituminous coal in large quantity under everyday conditions of mill operation and yet produce no smoke? There is a real and practical scientific answer to this question, which can be understood by pretty much everybody of fair intelligence, whether educated or not.

A lump of bituminous coal consists principally of a substance called carbon; another substance called hydrogen is also present. Now, the hydrogen does not exist by itself, but in union with some of the carbon. If the lump is suitably heated in such a way as to be beyond the reach of the air, the hydrogen, together with the carbon united with it, will pass off in the form of one or more gases. These gases are known as hydrocarbons—being combinations of hydrogen and carbon. A hydrocarbon gas with which many people are acquainted to-day is acetylene. But to get back to our lump of bituminous coal, there may in addition be some sulphur present in it. Now, every one of the substances so far mentioned can be burned. That is to say, the carbon, the hydrocarbons and the sulphur can, every one, be forced to combine with oxygen. When any one of them unite with oxygen, the result is a gas, not a solid. If we get smoke, we get what is largely a solid. That is to say, smoke consists largely of minute particles of carbon in the solid state. Carbon in the solid state in which it may be found in smoke is unburned carbon. If the carbon is burned, then we have no smoke. Pretty simple, isn't it? All you have to do is to make sure that all the carbon is really burned—that is, is forced to unite with oxygen.

Now, it has not been found very

practicable to accomplish this in a commercial way until comparatively recent years. To-day it is possible, as the example of the flour mill shows. The difficulties have been, no doubt, in part due to our ignorance of some necessary conditions. Let us consider briefly the principal facts and principles.

Consider the carbon first. When this substance is burned, or made to form a union with oxygen, we get either the gas, carbon monoxide (CO), or the gas carbon dioxide (CO_2). Whether we get the former or the latter depends largely upon how much oxygen we furnish. With other conditions as they should be, if we furnish 1.33 pounds of exygen for every pound of carbon, we shall get carbon monoxide. If we furnish 2.67 pounds of oxygen to every pound of carbon, we shall get carbon dioxide. There is a very great advantage, in respect to the amount of heat to be secured by burning the carbon with the double amount of oxygen. In fact, it has been ascertained that we get more than three times as much heat in this latter case. We shall not have any smoke in either one of the cases. It is an unalterable condition, however, that we supply at least the proper amount of oxygen.

Let us make a simple calculation. The oxygen used in combustion is ordinarily obtained directly from the atmosphere. Here, however, it is mingled with more than three times its own weight of the gas nitrogen. If we take 100 pounds of air, we shall have only about 23½ pounds of oxygen. That is to say, only about 23½ per cent. of the air is oxygen. To supply 1 pound of oxygen we must furnish $(1 \div 0.23\frac{1}{2} =)$ 4¼ pounds of air. Consequently, to burn 1 pound of carbon to carbon monoxide or carbon dioxide, we must supply $5\frac{2}{3}$ or $11\frac{1}{3}$ pounds of air. As we are ordinarily not desirous of burning the carbon merely to carbon dioxide, we see at once that what we have to do is to furnish over 11 pounds of air (150 cubic feet) for every pound of carbon.

In fact, we have to furnish much more air than this in practical everyday cases. The reason for this is as follows: In order that a molecule of carbon shall unite with two molecules of oxygen, it is necessary that the oxygen molecules and the carbon molecules shall get near one another. It is not sufficient that enough oxygen passes through the furnace. It is necessary to have the oxygen intermingled very thoroughly and in sufficient quantity with the carbon. Even if the oxygen were pure, and so mingled with no nitrogen, the thorough mixing would be necessary. It is not difficult to see, perhaps, that the great quantity of nitrogen seriously interferes with the coming together of the carbon and the oxygen. The usual method of overcoming the difficulty is to supply air in much greater amount than would otherwise be necessary. That is to say, we supply three or four times the amount of air that our calculations show is really needed. The great reason that forced draft facilitates combustion is because in this way a great amount of oxygen passes the point where carbon is available.

We should be quite practical if we estimate the weight of the coal or the weight of the carbon. This would be an over-estimation because of other substances really contained in the coal, especially the non-combustibles. Our error would, however, be on the safe side. We conclude, then, that we should furnish an amount of air weighing 30 or 40 times the weight of the coal. Neglect of this is to be regarded as likely to produce imperfect or incomplete combustion.

A second requirement of combustion is that certain temperatures must be attained. Different substances begin to burn at different temperatures. Thus, hydrogen will begin to unite with oxygen only when a certain temperature has been reached, carbon will begin at another temperature, and so on with other sub-

stances. Unless these temperatures are attained, combustion will not take place, however much oxygen may be present. This is a matter of very great importance indeed. Suppose, for example, that we have a mingled stream of air and one or more of the hydrocarbon gases passing through a furnace. You say: "Well, that is favorable to combustion." So it is, provided the requisite temperature is reached. If it is not, combustion will fail.

Consider a moment. When bituminous coal is heated, hydrocarbon gases are emitted. These should be at once mingled thoroughly with air. The arrangements in some furnaces are such that the mingling takes place, but before the whole of the mixture attains the necessary temperature it passes out into the flue. The part which does not reach the temperature of burning (the ignition temperature) will fail of combustion. Smoke will result.

Failure to burn is often brought about in the following way: The hydrocarbon gases are discharged from the coal and a sufficient supply of air is intermingled. These gases are then conducted to the boiler surface in such a way that the whole cannot reach ignition temperature prior to contact with the boiler. In such a case, combustion failure must certainly be expected. The reason for this is that the boiler surface exerts a cooling effect. The water side never reaches a temperature higher than, say, 300 or 400 degrees Fahr. Consequently, the side next the fire will be kept at a very moderate temperature. The only safe procedure is so to arrange matters that combustion takes place *before* the boiler surface is reached. This problem is solved, apparently, in more than one way. One method is to place fire and boiler surface wide apart. The object here is to provide time and opportunity for combustion. Another method secures the emission of the hydrocarbon gases and their mixture with air in a highly heated region of the fire box. This is the procedure where the under-feed idea is put into operation. While the coal is still below the fire proper it gets heated and sends forth the hydrocarbon gases. These rise into a region where air is supplied under pressure and where the temperature is very high. That this method may be a successful one is proved by the case of the flour mill referred to in the beginning of this article. The six boilers are each served by a pair of Jones' stokers, supplied by the Under-Feed Stoker Co. of America, Harris Trust Building, Chicago. If there were failure to burn the hydrocarbon gases the stack would undoubtedly smoke.

Another matter which has a bearing on smoke prevention is the preservation of uniform conditions. Suppose, for example, that I am feeding my fire with great regularity, supplying a very little coal at a time but without intermission. If I suddenly put on more coal than the fire can handle instantaneously, I shall produce a chilling effect. Smoke is to be expected as a result of lowering the temperature. I may, perhaps, produce much the same result by simply opening the furnace door. If I want to maintain a smokeless stack I must keep the conditions uniform. Undoubtedly, the best way to do this is by the use of a high class mechanical stoker. Now and then one could possibly find a man who had the judgment to handle the matter of stoking the fire in such manner as to prevent smoke. The mechanical stoker, however, feeds the fire without any interruption and with great evenness. Just the right amount of coal is supplied at a time.

The stokers in the mill referred to above are supplied, each of them, with an automatic valve so arranged that when an increased rate of coal feeding is needed, because of a change of condition within the boiler, the valve permits more steam to pass into the piston chamber of the stoker. This results in increased activity on

the part of the plunger which feeds the coal. There is no doubt that mechanical methods of stoking have come to stay, and that they are helping to solve the combustion problem.

The object of preventing smoke is twofold. In the first place, the smoke is very objectionable to other parties. Sooner or later the general public will see to it that municipal regulations forbid the generation of smoke. Besides, the manufacturer himself will want to avoid making his plant a public nuisance. There is, however, a second thing which will make perhaps a stronger appeal. The smoke issuing from a stack represents coal bought but not burned. It represents money spent and heat not obtained. The money loss due to smoke must be enormous. The loss incurred by a single factory for a single hour is perhaps no very great matter. But when this is kept up, hour after hour, day after day, it means that there is a steady stream of money flowing away.

Perfect combustion prevents smoke and the economic loss represented by smoke, but it accomplishes a further economic saving. The object of combustion is to get heat. By perfect combustion—that is, combustion thorough and complete—we get all the heat possible. Heat is generated, or liberated, ordinarily when two substances combine with each other to form a chemical compound. For example, suppose you mix two cubic feet of hydrogen gas with one cubic foot of oxygen. If you then set fire to the mixture, say by means of an electric spark, you will get heat when the two gases go together to form water. It is the same when carbon and oxygen unite; we get heat from the combination. Now, different substances produce very different amounts of heat when they unite with oxygen. Hydrogen produces an enormous amount of heat, if we supply it by weight. Thus, one pound of hydrogen when burned will produce enough heat to raise the temperature of 62,000 pounds of water 1 degree Fahr. Or, if we wish to speak in technical language, we say that one pound of hydrogen has a heat-producing capacity of 62,000 British thermal units, since a British thermal unit means the amount of heat required to raise the temperature of one pound of water 1 degree Fahr. The hydrocarbon gas known as acetylene is also a great heat producer; one pound of acetylene produces when burned 21,850 British thermal units. No doubt, a great deal of the heat obtained from burning bituminous coal comes from the hydrocarbon gases of which acetylene is one, but the chief source of heat is the carbon. This substance, uncombined with anything else, makes up the greatest part of the weight of the combustible ingredients of the coal. Now there is a very curious fact about the combustion of carbon. It can be partially burned, or it can be completely burned. This fact has already been stated in some shape. The amount of heat produced is very different. If one pound of carbon is burned partially—that is, so that the result is carbon monoxide (CO)—then we shall get 4,400 British thermal units; but if it is completely burned—that is, so that carbon dioxide (CO_2) results—then we shall get 14,500 British thermal units. In other words, if we do not burn our pound of carbon completely, we shall lose 10,100 British thermal units. We lose 70 per cent. of the heat which it is possible to get. This, of course, ought not to be. With this loss smoke has little or nothing to do. If your stack smokes, you are certainly losing money; if it doesn't smoke, it is still possible that money is being lost. However, there is ordinarily no real need to lose money either way. The great reason why carbon is not fully burned is that insufficient oxygen is supplied. If, for every pound of carbon, we supply $5\frac{2}{3}$ pounds of air (75 cubic feet), we cannot expect to burn it further than to carbon monoxide. We are supplying only enough air to accomplish

that result. Indeed, this amount will be required even if the provisions for mixing are absolutely perfect. The way to govern the matter is to provide air in such quantity that no carbon monoxide is coming from the stack. There are methods of testing this, and they should, of course, be employed. If it becomes necessary to supply by provisions for natural draft or by blowing arrangements two hundred or more cubic feet per pound of coal, it should ordinarily be done. Heat is then being gotten which would otherwise be lost.

The successful mechanical stoker secures completeness of combustion, as has, perhaps, been already intimated, largely through the evenness with which it feeds the fuel. Stoking machines may be divided into classes upon the basis of the various methods of feeding. Thus, there is the front feeds, where the coal is fed from the front toward the rear and at the same time from a higher level to a lower one, dependence being placed partly upon gravity. Then there is the side feed, where the coal is likewise fed from a higher to a lower level. There are, however, two tilted grates which feed the fuel toward each other. The chain grate stokers are somewhat similar to the front feed machines in that they operate from front to back. They put little or no dependence upon gravity, the grate being level, or approximately so. Such a stoker is an endless web arranged on two sprocket wheels, the onward movement being effected by mechanical means. Then there is the under-feed stoker, which differs radically from all of the others. With it the fuel is fed to the fire from below. The fuel is contained in a long trough. The fire is maintained at its upper level, forced draft being introduced here through suitable openings. This is the type of stoker used at the flour mill referred to at the beginning. In this particular variety of under-feed stokers the feed is mechanically accomplished through the agency of a ram operating in the bottom of the trough-like reservoir. As it moves backward and forward, fresh coal is brought in little by little. The movement is secured by means of a piston.

THE RAILWAYS OF SOUTH AMERICA

I. NORMAL GAUGE RAILWAYS ON THE EAST COAST (URUGUAY, PARAGUAY AND A PORTION OF ARGENTINA)

By R. Renewal

NORMAL gauge railways are exceptional in South America. Peru, on the west coast, Uruguay, Paraguay, and the intervening Argentine provinces use it alone.

There is no doubt the adoption of the 4 feet 8½ inch gauge is not justified on that Continent. It is too small a gauge for heavy traffic (its limitations having been felt long ago) and the meter gauge answers the same purpose as well and with a lesser outlay. This somewhat subversive statement wants some backing up, and so as not to "pick out" exceptional cases we will compare these normal gauge roads with the neighbouring meter gauge lines in Argentina and Brazil. The difference in cost of construction is evident.

The following table shows distances, total time and speed:

NORMAL-GAUGE LINES

Line.	Distance.	Time.	Speed, Miles Per Hour.	Company.
Montevideo to Rivera	352	19:43	17	Central of Uruguay.
Montevideo to Melo	261	15:20	17	Central of Uruguay.
Montevideo to Mercedes	186	9:24	20	Central of Uruguay.
Montevideo to Sauce	125	7:15	17	Central of Uruguay.
Montevideo to Colonia	153	8:05	19	Central of Uruguay.
Rio Negro à Salto	197	11:55	16	Midland of Uruguay.
Salto to Quarahy	109	7:00	15.5	North Western (Uruguay).
Ibicuhy to Concordia	215	11:53	18	Entrerios (Argentine).
Concordia to Posadas	372	18:30	20	North Eastern (Argentine).
Concordia to Corrientes	328	15:00	22	North Eastern (Argentine).

METER-GAUGE LINES

Rosario to Santa Fé	101	4:15	24	Santa Fé (Argentine).
Santa Fé to Barrancas	351	16:00	20.5	Santa Fé (Argentine).
Porto Alegre to Santa Maria				Rio Grande Ry. (Brazil).
Santa Maria to Uruguayana	232	11:15	21	Rio Grande Ry. (Brazil).

All timings include stoppages, the speed being the actual commercial speed.

Taking similar distances on both gauges, it is apparent there is no advantage in favour of the normal gauge.

As regards capacity of the rolling stock, the same is apparent. The southern Brazilian roads' standard freight cars carry 28 tons, which is exceeded but by a few cars in Uruguay, carrying 30 or 35 tons.

I do not argue this could not be bettered (and, as a matter of fact, so could the meter gauge roads), but that, given South American conditions, either road answers all requirements equally. This does not apply to the broad gauge, which is an entirely different proposition.

There is yet another point to consider in relation to gauges—that is, interchange of traffic. Military reasons, if any, dictated Uruguay's choice. Also the fact these roads were built by British companies. The isolation has worked but partially, as Argentine has laid its neighbouring lines to that same gauge. Commercially this is not much of a hindrance. It should be borne in mind journeys are usually very long, and therefore rather costly, so that the waste of time and money involved in transhipping freight is slight compared to the total outlay involved. It should also be remembered the ca-

pacity of the freight cars is similar, making it easy to run movable bodies which could be swung from meter gauge to normal gauge trucks, at the frontier stations, should the need of running through loads be felt.

These primary conditions understood, we will now proceed to examine the normal gauge systems of Uruguay, consisting of the whole of its railways, and of the Argentine Republic.

THE RAILWAYS OF URUGUAY

The Oriental Republic of Uruguay is, taking it altogether, a large expanse of undulating country, almost entirely given over to pastures where cattle—and good cattle—is raised, and to fields of various agricultural productions. Such being the case, the necessary corollary is the attraction exercised upon the outlying tracts by various centers, and the connection of these centers with a decent harbour, the capital of the country in this case.

On the other hand, the geographical situation of Uruguay, at the tail end of the United States of Brazil, and surrounded on its three other sides by the ocean and the Argentine Republic, make the building of railways dependent on military conditions, it being expedient to connect the center—Montevideo—with the frontier at convenient points.

Both conditions harmonize, hence a radial system of lines, spreading from Montevideo fanwise inland, with practically no cross-country connections. That is the reason why, though the general plan of railways was laid out so long ago, it has been kept to. The development of a single center of attraction precludes any call for other roads, gradual evolution, when it will take place, necessitating but the building of other radial lines between the original ones, starting from a point where they diverge too much.

There is, therefore, little likelihood of diagonal or cross-country roads being built, though there has always been much talk of constructing such lines, unless local necessities, and particularly mines or mining industry, should develop.

There are now 1,522 miles of railways, all British, open to traffic, 973 of which are in the hands of the Central Railway of Uruguay, 471 miles belong to the Midland group, and 78 more to two small independent companies, the Great Eastern Railway and the Montevideo Northern.

This railway system is the modern outcome of two important railway acts, the first dated 1872 and the latter 1884.

The 1872 bill appointed a commission of six members (Antonio Monterro, Carlos Honoré, Juan Alberto Capurro, Carlos Olascoaga, Emilio Dupré and Enrique Penote) to draw up the general railway scheme, which was pased on August 27, 1884, as follows:

Line that Was Decided.	Name.	Present Company Working the Line or a Portion.
Montevideo, Rivera	Central	Central Uruguay.
Montevideo, Artigas	North Eastern	Central Uruguay.
Montevideo, Port Ceboblati	Eastern	Central Uruguay.
Montevideo, Fray Rento	Western	Central Uruguay.
Extensions:		
Passo de los Torros, Salto, and branch to Paysandu	Midland	Midland group.
Salto, Santa Rosa	North Western	Midland group.
Isla de los Cabellos, San Eugenio Diagonal	Northern	Midland group.
Colonia to San Luiz	Interior	Project (Interior).

The first concessions differed as to the help afforded by government, but such help was always forthcoming, and was particularly necessary in a country where political disturbances were so frequent. Between the years 1825 and 1910, there have been no fewer than forty-nine revolutions, besides several strikes. True, they are not very serious, nor is there much bloodshed, but they unsettle things, and do a good deal of damage to railway property. Then, freight is almost entirely made up of agricultural products, and is therefore de-

pendent on the weather, locusts and various other items, independent of the railway's management or organization. This is hard on a line, as its earnings may be low, through no fault of its own whatever.

The general technical conditions, ruling all the early lines, are given in tabulated form, which is easier for reference:

Maximum gradients: 1 in 83, and exceptionally, 1 in 62.
Minimum radius of curves: 440 yards, and exceptionally, 330.
Length of tangents: At least 110 yards.
Minimum width of roads under bridges: 8 meters (26 feet).
Minimum height under bridges: 5 meters (16 feet) if masonry; 4.50 meters (14.7 feet) if metallic.
Railroad under road bridge:
Clearance, 10 meters (33 feet).
Width, 8 meters (26 feet) for double track; 4.5 meters (14.8 feet) ior single.
All crossings at an angle not smaller than 45 degrees.
Tunnels:
Height, 6 meters (20 feet) at center, and 4.5 meters (14.8 feet) outer rail
Width, 8 meters (26 feet) in all cases.
Rail: Weight not under 60 pounds per yard.
Sleepers not further apart than 3 feet.
Gauge, 4 feet 8½ inches.
Ballast to be 1 meter wider than outer rails.

Apart from the very first lines, all of which had special favours, the usual guarantee was 7 per cent. on a kilometrical cost of not over £5,000. Any sums so paid by government should be reimbursed by the company as soon as dividends reached 8 per cent. on the recognized capital. Government might expropriate the line after twenty-five years, paying the value and 20 per cent. of the earnings.

The guarantee system was altered on Nov. 28, 1888, the guarantee running thirty-three years only; on the other hand, it might apply exceptionally to £7,000 per kilometer, the average remaining at £5,000. Government might cut down the rates should dividends exceed 8 per cent. on the portion corresponding to this excess.

A more important clause stated that all lines should revert to Government after ninety years.

Economical railways were also decided, built to the 2-foot gauge at a cost not exceeding £3,000 per kilometer, and this same law also provided for the building of roads on Government's account. Neither of these two classes of roads has been proceeded with.

The guarantee system was again altered in 1891, and the guarantee reduced from 7 to 3½ per cent. on £5,000 per kilometer. This curtailing of original favours is noticeable in all countries where it has been necessary to artificially stimulate railway enterprise.

Should dividends be lower than 1½ per cent the company receives the 3½ per cent; between 1½ and 5 per cent., the sum paid by Government is reduced; the sums between 5 and 6 per cent. are retained by the company; two-thirds of the sums between 6 and 8 per cent. are reimbursed to Government; and the whole of any dividends exceeding 8 per cent.

Up to Jan. 1, 1893, the guarantee system had cost Government 27,505,969 pesos for 829 miles of railways.

In 1911, 1,649 kilometers (1,022 miles) of railways were under guarantee, out of a total of 2,455 kilometers (1,522 miles). The service of guarantee amounted to $702,086, giving an average cost of guarantee per kilometer and per year of $474.67. This cost has been decreasing, the original earning better dividends, which is a witness to the development of the country, as under:

1906-1907	$572.46
1907-1908	553.86
1908-1909	497.14
1909-1910	456.02
1910-1911	474.67

this latter increase being due to the opening of three new guaranteed sections: Algorta to Fray Bentos (105 kilometers, or 65 miles), La Sierra to Maldonado (64 kilometers or 40 miles), and the first section of the

Treintay Tres extension (50 kilometers or 31 miles).

The nominal guarantee is $822.5, which is considerably more than the actual one, as the above figures show.

The amounts which may be necessary for the payment of such guarantees are taken from the customs dues, 45 per cent. of which are remitted to London for the purpose and for the payment of Uruguay's Consolidated debt.[1]

1901-1902	$9,605,690
1902-1903	10,020,181
1903-1904	9,275,586
1904-1905	10,196,089
1905-1906	12,728,594
1906-1907	12,965,792
1907-1908	13,380,795
1908-1909	13,861,898
1909-1910	15,001,639
1910-1911	15,542,854

How this has answered in practice is shown by the present development of railway traffic in the republic. The figures quoted below refer to the railway year ending June 30, 1911:

Kilometers of railways, 2,454,638; 1,454,318 passengers were carried 83,955,085 kilometers, and of these over half (53.07 per cent.) traveled first class; 1,571,335 tons of freight were dealt with, traveling 246,545,805 kilometers, and of these there were 316,816 tons of live stock, comprising 1,672,265 heads, 408,000 tons of produce, 400,000 of building material and 294,000 of general merchandise.

The net receipts were $5,829,715, and net profits $2,520,271, corresponding to a 56.77 per cent. working percentage.

The total capital invested in the railways was $78,355,119.

A CENTRAL URUGUAY SYSTEM

The Central Railway of Uruguay is the most important and is made up of a main line, running due north to Passo de los Torros (now called Rio Negro), with a few branches, and several extensions, operated or leased.

The original concession was granted in 1865 to Sr. M. Rodriguez (decree of Oct. 4, 1866) from the "Union Town" (Montevideo) to Piedras, Calones, Santa Lucia, Florida, and Durazno, whence it should be extended to the frontier. The guarantee was 7 per cent. on £10,000 per mile, during forty years, during which lapse of time the road would be exonerated from all taxes or import duties. The same guarantee applied to any branches that might be built, an interesting clause stating that 55 per cent. of the rough earnings would be considered working expenses. This indispensable corollary of the guarantee system is often left out (this being the case in Brazil).

The pecuniary means used to help the early efforts towards railroad building are rather striking. Government subscribed 2,000 shares, paying £2,000 monthly, and the railway undertook to reimburse this advance, with any earnings above 7 per cent. on the invested capital. The departments were obliged to pay half of any deficit should such incur. On the other hand, Government might lessen the tariffs should dividends reach 16 per cent.

The law of Jan. 14, 1868, authorized the transfer of the road to the "Central of Uruguay Railway" of London. The guarantee was extended to 8 per cent. on the actual cost, but this clause was received with disfavour and the road was built to Durazno under the 1866 clause.

This first section is 204.8 kilometers long (127 miles), crossing the Rio Santa Lucia on a long bridge at the 39th mile, the Rio Pintado at the 68th mile on a 184 meter bridge, consisting of five 120 feet spans, and finishing on the hither bank of the Rio Yi.

Several of these early bridges did not allow sufficiently for floods, and though the Rio Santa Lucia bridge consisted of twenty 15-meter spans (49 feet) and four 24-meter spans (79 feet), making a total of 396 meters (1,300 feet), the bridge was

[1] The annual amounts of the total customs revenue were:

damaged in 1900 and reconstructed between that year and Jan. 5, 1902, when it was reopened for traffic. It now consists of seventeen spans of 15.24 meters (50 feet), three of 25.91 meters (85 feet), and five of 52 meters (171 feet), altogether 601.8 meters (1,975 feet).

The company was reorganized on Feb. 25, 1878, and renounced the guarantee of interest in exchange of $5,000[1] paid six monthly during ten years. This agreement also stipulated a further extension northward, Government giving up its shares and turning the concession into a perpetual one.

The line was extended to the other bank of the Rio Yi in 1879, which was effected by the erection of one of the largest bridges in the country, consisting of no fewer than forty-one 50-foot spans (625 meters) altogether. These same spans are used practically for all the bridges along the whole line, which is an excellent plan.

A further extension to Rio Negro was opened on Feb. 1, 1887. It had been conceded on Sept. 24, 1884, in compliance with the general railway act, Government contributing £500 per mile in 4 per cent. bonds which were to be reimbursed with the surplus on 8 per cent. of the *entire* line after the year 1886. Rio Negro, which is situated on the banks of the river bearing the same name, and in the very center of the Republic, is the northern terminal of the Central of Uruguay's main line. The proposed extension, further north, was handed over to Messrs. Greenwood & Co. (ratified by decree of August 31, 1888), who floated the "Central of Uruguay Northern Extension Railway" with £1,000,000 capital in shares (£700,000 of which were issued). This company leased its line in perpetuity to the Central of Uruguay Railway on Oct. 26, 1888 (approved by Government June 16, 1890).

Such is the basis of the "extensions" regime as practiced in the Oriental republic. It unburdens the original route, that profits by their opening. On the other hand, these extensions are thus left entirely to their own resources, and such guarantees or rentals as they may have making money raising more arduous.

The building of this line involved the construction of a bridge across the Rio Negro, the largest of the State. It is, in fact, 2,375 feet long, consisting of twenty-two 60-foot girders and nine 120-foot spans, supported by stone piers. The girders are trellis work at a great height above the river bed. The annual floods rise 24 feet above the ordinary level, and exceptional floods as much as 15 feet more above that.

As the line runs north it penetrates into more broken country crossing the Tambores mountain range, between the 412th kilometer (256th mile) and Rivera, 567th kilometer from Montevideo (352d mile) at the frontier. This range is mostly volcanic and involved some rather heavy work, and the construction of a short tunnel, the only one in the State. This must be the reason Government insisted upon its being lined throughout with masonry, which was absolutely useless considering the nature of the rock. It is 792 feet long, on a 1,640 feet radius curve.

Rivera is the Uruguayan portion of a town whose other half is in Brazil, and is called Santa Anna de Liveramento. They are separated by a wide street, and, curiously enough, the difference between the two portions is striking. The Rio Grande Railways in 1910 opened a meter gauge line from Santa Anna to Cacequy, forming through connection with the north, the only gap being some 1¾ miles between Rivera and the frontier. The connecting link is ready on the Brazilian side of the frontier and the Central of Uruguay Railway hopes to finish its portion shortly. The section between the two frontier stations and these stations is to be provided with three-rail tracks.

[1] The Uruguayan peso is practically equivalent to the American gold dollar.

But to return to the early railway development:

A few other roads had been opened previous to 1884 (13 kilometers or 8 miles of the Sao José branch, 69 miles of the North Western, 21 of the North Eastern, and 14 of the Northern to Santa Lucia), so when this act came into force it became necessary to alter some of the original concessions. These were reduced from perpetuity to 90 years, guarantees from 40 to 33, Government interfering in the tariffs only for the portion corresponding to its share above the 8 per cent. The right of expropriation could be exercised any time on valuation instead of after 25 years only.

Western Extension.—The San José branch of the Central Railway of Uruguay starts from a town called 25 de Agosto, running westward 21 miles. This line, which was opened in 1876 (on May 20) is the old F. C. à Higueritas, represented by Baring Brothers, of London. There was a 7 per cent. guarantee of interest on £10,000 per mile.

It was purchased by the Central Railway for £110,000 in £10 shares and who renounced the guarantee as they had done for their own line, in exchange of 700,000 pesos in bonds. the same law (August 30, 1888) provides the road should be assimilated to those granted under the 1884 general railway act.

The town of San José is on the further bank of the Rio San José, which the line has to cross. This was effected by means of an iron bridge consisting of eight 50-foot spans and nine 36-foot ones, with a total length of 724 feet, supported on 16-inch diameter columns. During the floods of March, 1900, two 50-foot spans were washed away, and found 40 yards down stream in 20 feet of water and embedded in sand, where they have had to be abandoned.

A temporary timber structure was erected across the gap, traffic being reopened on May 21, 1900. Some time afterwards a temporary low level bridge, with approaches, was built, while work was in hand on the metallic structure, completed on June 26, 1903. It was lengthened at the west end with three new spans, making altogether four 50-foot through girders, eight 36-foot deck girders and three new through girders, two of 121 feet and one of 97. The total length is thus 827 feet. These new spans are supported on 7-foot cast iron columns, sunk down to the rock level through 8 meters of sand and 7 of soft marl and 5-foot diameter columns fixed above water level and connected to the 7-foot columns by a specially designed tapering section. The companion column of each separate pier was secured together by means of a diaphragm plate. The columns are all filled with concrete.

This construction is typical. It is interesting to compare it with the discontinuous Warren girders resting on stone piers, also typical, of Belgian and French construction in Brazil and the Argentine.

The line has been further extended westward, and though this has been accomplished at a much more recent date, and is a separate undertaking, it was projected quite at the outset. There are a number of towns beyond San José, both on the seashore and in the interior; and as there is little to choose between them, there has been a good deal of hesitation as to which should be connected by the main line and which left to branches. In such cases, local influence is apt to have too much play, hence the delay in construction work.

In 1884 the Railway Act had provided for the building of a line through Rosario and Mercédes to Fray Bentos, with three branches to the seashore, from Rosario to Colonia, from Perdido to Palmira, and a third one to Dolorés.

The Sauce, Rosario and San José

"loop line" had been conceded to Lacaze without any guarantee as a different undertaking. Its length was to be 86 kilometers (55 miles).

The "Western Line and Branches" were to be constructed on Government's account, at a cost not exceeding £6,000 per mile, payable in bonds of the 85, 6 per cent. and 1 per cent. amortization. The right to construct a port in Colonia and another in Sauce was granted.

However, apart from the Sauce Harbour and Railway Company's line, opened in 1899, nothing had been done. The Central Railway acquired the "Western Railway" line from San José to Sauce, with their rights for building the Mercedes branch and termini in Colonia and Sauce, for £757,500 and £862,500 in 6 per cent. debentures of the Western Extension Company, which they floated in the same way as the other extension companies, the only difference being that the Western Extension held a 60-year lease only, running from the date of opening to traffic (Jan. 1, 1902).

The extensions, which were expected to cost £4,000 per mile, cost £6,000.

The system consists of the main line from San José to Mercédes (127 miles) on the banks of the Rio Negro, near its mouth; a branch from Mal Abrigo to Colonia (71 miles) opposite to Buenos Aires, the distance being 31 nautical miles only, and the Sauce branch, which connects the small town of Rosario with Sauce Harbour, 55 nautical miles from Buenos Aires. This branch is 13 miles long.

The whole system has, therefore, both river and maritime traffic to contend with.

Ocean-going steamers can reach Mercédes. There are two other harbours near by which have also been improved of late—Fray Bentos, belonging to the Midland Railway, and Uruguay, on the Entrerios Railway of Argentine.

North Eastern Extension.—We have been over the Northern and Western Extensions. Eastward work had progressed in the same way, an outcome of the Montevideo and Minas Railway, one of those granted in 1884 by the general railways act.

Messrs. Rezende and Baena had built the Ferro Carril Uruguay del Este from Montevideo to Pando (37 kilometers, or 23 miles), when Jeffries applied for a line from Pando, Caleones or Piedras, right out to Artigas, on the north eastern frontier, with a branch to Treinta y Tres, and leave to build one, if he wished, to the town of Minas.

There was some trouble at first with the Pando Railway, but an agreement was come to whereby Jeffries took over that road. But he was unable to proceed any further, so on July 30, 1887, Mr. Edward Cooper floated the "North Eastern Uruguay Railway," who built the line as far as Minas (55 miles from Pando), opened it to traffic on Jan. 6, 1889, and leased it to the Central Railway for 999 years from Feb. 15, 1889, as the "North Eastern Branch," afterwards incorporated in the North Eastern Extension.

The Central Railway had previously built a link line between its station of Treinta y Tres (10th mile) and the North Eastern's station of Sayago. This short line is 5 miles long.

There are a few bridges on the North Eastern Branch (Rio Salis del Medio, 492 feet; Rio San Francisco, 344 feet), but no great engineering works of any kind.

The concession handed over to the Central of Uruguay Railway comprised the Artigas line, which it took in hand, altering the starting point to Toledo. This line was given over to another extension company, the "North Eastern Extension" (Feb. 20, 1889), with a capital of £1,000,000, and which was worked in perpetuity by the Central Railway of Uruguay at an annual rental of £56,000 (June 16, 1890).

The length of the line to Nico

Perez is 128 miles, mostly across pretty easy country. There is a 1,396-foot bridge at San Ramon over the Rio Santa Lucia, comprising twenty-three 50-foot spans and three 80-foot spans.

Construction work was then discontinued for a very long time, owing partly to the constant political disturbances and partly to the method of calculating the guarantee on the sliding rule basis. Owing to the difference between the two contracts (with Government and with the Central Uruguay Railway) it so happened that if gross earnings increased, dividends diminished, hence the lukewarmness in extending the line.

These conditions were amended by the new contract (April 10, 1906). Dividends up to 6 per cent. should be paid, and of the surplus Government should have two-thirds and the company one-third. Also, beyond Nico Perez, Government guarantee covered 45 per cent plus 88$50 per kilometer, instead of 40 per cent. plus 87$30 per kilometer, as on the previous section.

Construction was once more started and the sections opened as follows:

	Miles.
May 15, 1908—Nico Perez to Cerro Chato...	174
Nov. 15, 1908—Cerro Chato to Tupambaé..	207
June 18, 1909—Tupambaé to Melo.....	261

Melo is not very far from the frontier, but here the line stops owing to the views of Uruguay and Brazil clashing. The original Uruguayan line was to run to Artigas, and Brazil is building one from Jaguarao, the sister town across the river, to Bazilio, on the Rio Grande do Sul Railway. The direction given by the builders of the Central of Uruguay Railway seems to point to some other frontier station, probably Centurion, more to the west, and a second line from the Brazilian frontier to the Rio Grande system would not pay.

The branch from Nico Perez to Treinta y Tres was opened last year.

Central of Uruguay Railway System.—Having described the various lines now forming the "Central group," we will proceed to examine the system, which is made up of the following sections:

Line or Section.	Company or Extension.	Miles.
Montevideo to Rio Negro	Central of Uruguay Railway	170
25, de Agosto to San José	Central of Uruguay, branch	21
Sayago to Treinta y Tres	Central of Uruguay, link	5
Rio Negro to Rivera	Northern Extension Line	182
Rivera to the frontier	Northern Extension, projected	2
Montevideo to Minas	North Eastern, branch	76
Toledo to Nico Perez	Eastern Extension Line	130
Nico Perez to Melo	Eastern Extension Line	115
Melo to Centurion	Eastern Extension, projected	...
Nico Perez to Treinta y Tres	Eastern Extension, branch	64
San José to Mercédès	Western Extension Line	126
Mal Abrigo to Colonia	Western Extension, branch	72
Rosario to Sauce	Western Extension, branch	13
Total open to traffic	Whole system	973

There is another short line that should be taken at the same time, because it is really but an "independent extension" of the system. This is the "Great Eastern Railway" from Olmos, on the North Eastern or Minas Branch, eastward. I purposely say "eastward," because it stops on the way and does not lead at all where it was intended to. It runs 31 miles to La Sierra, and has been constructed in 1911 only to Maldonado, at the 68th mile. The object was to run it 190 miles further, to some town on Lake Mirim, a coast line very similar to the Colonia line. But a 7 per cent. guarantee of interest on a limited amount per kilometer was not sufficient inducement to get it concluded, though it covered the total $10,204,276 gold capital.

The Central Uruguay system is laid in 65 and 80 pounds steel rails, the lighter rails being gradually removed. The first 12 miles or so out of Montevideo were originally laid with 70 pounds bullheaded iron rails on cast iron sleepers (in 1869), which remained in use until 1882, when this section was renewed with 61-pound steel-flanged rails on creo-

soted pine sleepers. Nor is this section the only one in South America where pot sleepers were used, some of these still being in service on the North Eastern Railway of Argentine.

The sleepers were originally pine or creosoted pine. In 1883 various South American hardwoods, oak and creosoted pine were intermixed with the old half round pine sleepers in a renewal between Piedras and Duraxno. A second experiment on a large scale was undertaken in 1886 between Yi and Rio Negro, half the sleepers being quebracho. These hardwoods have shown themselves so superior that all removals are made either with Australian jarrah or South American hardwood, quebracho being the most satisfactory.

Steel trough sleepers have been laid with the 80-pound steel rails, the turnout and crossings with hardwood, which is a good combination.

The standard crossing angles vary from 1 in 8 to 1 in 10, but there exist some from 1 in 5 to 1 in 14. The turnouts having crossings of 1 in 8 or under have switches 12 feet long. Those of 1 in 8 or more have switches 15 feet long.

Superelevation of the outer rail in curves is allowed for a speed of 60 kilometers. As the sharpest curve radius on the main line has a radius of 300 meters, the greatest superelevation is 10 centimeters (or 4 inches). In curves under 600 meters radius the rails are spread out to 4 feet 9⅛ inches (1.451 meters).

The principal works of art are the bridges, of which we have already said a few words. The assumed rolling loads used in the calculations range from 1.5 tons per foot, in the case of long spans, to 3 tons for the short spans. The assumed figures include allowance for impact.

The largest of these bridges are as follows:

Rio Negro	755.73 meters	(247.9 feet)
Rio Santa Lucia	601.81 meters	(1,974 feet)
Rio Yi	623.25 meters	(2,045 feet)
San Ramon bridge	423.66 meters	(1,390 feet)
San José bridge	252.00 meters	(827 feet)
Mansavillagra bridge	132.40 meters	(434 feet)
Pintado bridge	184.14 meters	(604 feet)

There are no retaining walls of any importance, and but a single tunnel, on the Rivera line.

The Central of Uruguay Railway has erected in Montevideo a fine modern station. It was constructed in 1878 by Mr. Andreoni at a cost of £140,265.

The covered portion is 150 meters long (492 feet), 85 meters broad (279 feet), and covers an area of 12,750 square meters (137,245 square feet).

The working of the trains is controlled since 1906 by the automatic lock signaling system, whereas the running of the trains in the other stations is governed by the ordinary telegraph system. Each station is supplied with two distant signals.

The rolling stock consists of 109 locomotives, 89 coaches, 78 vans and 1,897 freight cars (on June 30, 1911).

Quite a number of these were constructed at the company's works at Penarol, on the Sayago and Treinta y Tres branch, near Montevideo.

The standard trucks run on 3 feet ½ inch wheels, with 3½ × 8½-inch axle bearings. The automatic vacuum and hand brakes are fixed to the coaching stock. This includes sleeping cars, divided into compartments on the usual European pattern, and several dining saloons. Stone's system of electric lighting is used.

Two classes of freight cars deserve special mention. These are covered wagons, having 14,670 kilos tare weight and 35,500 capacity, and freight cars weighing 13 tons and carrying 30 tons.

The workshops use 900 workmen.

Traffic returns on the combined system have increased continuously. During the year 1910-1911, 1,335,834 passengers were carried, bringing in £280,705, and 964,000 tons of goods were handled. These consist mainly of:

	Tons.
Hay and grain	25,691
Stone and material	269,838
Wool and sheepskins	59,022
Hides and skins	13,262
Flour	17,957
Cereals	146,812

A large number of animals are carried as well, totaling 1,172,037 heads, 528,633 of which are cattle and 598,212 sheep. The cattle are either turned into extract of meat, or else into jerked meat, treated in the same way as in Southern Brazil. The cattle trains, also, are similar. The cars are closed by end guillotine doorways which can be raised, a flap falling across so as to bridge the gap between the flooring of two cars, and small side doors bridging this gap laterally. This turns the whole train into a long corridor, down which the half wild animals are driven, the guillotine being closed as soon as each car is loaded. The sides are lattice work and the roofs open.

There is a good passenger service out of Montevideo, 24 trains leaving and as many arriving each day. The cars are good and comfortable. But the passenger service in the interior is quite exceptionally slow, and has wanted brightening up for quite a time.

The tariffs are, on the whole, lower than most of those in force in the Argentine Republic.

Here are some data per train and per mile, showing what the traffic brings in:

Receipts per mile	£1,091
Expenses per mile	578
Profit per mile	512
Receipts per passenger	4/ 2.42 d.
Receipts per ton	12/ 18.32 d.
Vehicles per train	23.14
Coal per engine mile, pounds	43.87

The working coefficient of the system keeps near 50 per cent., or, to be more accurate, has risen from 45 to 53 per cent. between 1902-1903 and 1910-1911.

The gross earnings were £1,017,-403; the working expenses, £539,-498.

Apart from the works now in hand, the company does not contemplate any extensions.

(To be Continued)

LOOKING FORWARD

EDITORIAL NOTES ON IMPENDING DEVELOPMENTS

Manufacturing Processes

In the manufacture of the various necessities and luxuries which constitute the greater portion of our industries there has been a tendency of late to endeavour to develop, so far as possible, direct methods and to skip the slower natural processes which have formerly been employed. Whether this is a forward step or not, remains to be seen, but it is a tendency which will have to be considered if any continuous view of coming developments is to be taken.

Formerly practically all transformations and combinations were effected by Nature alone. The primitive man depended for his food upon such edible fruits as he could find, and such animal food as he could procure. As agriculture advanced, he found that the productiveness of the ground could be maintained by the use of animal manures, and later he discovered that some other kinds of fertilizers could be found in the ground itself. For dyestuffs he used coloring matter found in plants and in shellfish, for clothing he employed the skins of animals, and later he made woven fabrics from vegetable and animal fibre. All these things are still done, but to them have been added a number of products made from their constituents by processes more direct and more rapid than the deliberate methods of Nature.

Most of these modern processes have originated with the development of the modern science of manufacturing chemistry. It is true that the alchemists endeavoured principally to produce the precious metals directly, failing to perceive that the value of such substances depended largely upon the limitations which Nature had set upon their amount. The modern chemist, with a better head for business, has attempted to produce things which have a value in themselves, and which, if produced in such quantities as to lower the price materially, will simply benefit humanity to a corresponding degree.

Thus, the successful work of Birkeland and Eyde, in Norway, in producing nitric acid directly from the nitrogen of the air, enabling nitrate fertilizers and other nitrates to be manufactured by power, is rendering various parts of the world independent of the deposits of nitrates in Chile. Formerly, it was taught that the nitrogen of the air was one of the most useless things in existence, and that about the only service it rendered was to dilute the oxygen of the atmosphere to a degree suitable for breathing. Today it is known as an inexhaustible storehouse of material from which many valuable compounds may be manufactured.

This is but a single example of the development of synthetic methods in a rapidly extending list, which includes camphor, ammonia, indigo, and many other substances, and to which is now added synthetic rubber.

In some instances, such as the case of synthetic camphor, the appearance of the new material has so stimulated the older method of production that investigations have shown the way to improve production and permit the new competition to be effectively met. Whether this will be generally true cannot yet be determined, but in general the influence of competition may be expected to appear in some degree.

If, however, any determined attempt is to be made to replace the slower pro-

cesses of Nature by more direct and rapid artificial methods it might seem advisable to aim directly at the mark, whenever possible, rather than at some intermediate point, and try to produce the final product instead of one of the indirect means. If a fertilizer, to replace in the soil the elements which the crop has abstracted, may be artificially produced, why not attempt to combine the constituents of the food product itself, and thus leap entirely over the intermediate operations of vegetation? If we can use power to effect the combination of inorganic matter, to form organic compounds of one kind, why not go the whole way, and make the food directly? These questions sound absurd, but not more so than similar inquiries would have sounded a few years ago about radio-telegraphy, aeroplane performances, or similar commonplaces of to-day. Any study of the development of any department of applied sciences will reveal, to a marked extent, the manner in which effort, time and money have been expended upon operations which proved subsequently to be unnecessary, and capable of being entirely swept away when the ultimate nature of the problem was broadly considered. It might be advisable to begin any undertaking with a similar broad survey of the problems which are before us to-day, and not continue to follow the older and less efficient methods.

Mechanical Revivals

It is sometimes interesting to observe the manner in which certain ideas and inventions which fell almost unnoticed when first projected have been subsequently revived and developed to success and usefulness. It might be supposed that engineers who themselves are fully aware of the defects and shortcomings of the apparatus with which they are working, would be among the first to perceive the value of improvements which are spread before them, but often the most valuable ideas are ignored until years have passed, and then are reinvented, and the older devices remain curiosities of mechanical history. In looking forward for engineering developments, therefore, it may be worth while to take into account some of the ways in which old devices have been revived in the light of modern methods of design and construction, and obtain a possible guide to repetitions of such revivals.

One of the ingenious inventors of the early part of the nineteenth century was Jacob Perkins, an American who spent much time in England and there brought out a number of steam devices which attracted some attention at the time. His work was mainly directed toward the generation and application of high pressure steam, and as at that time the standard practice of the older engineers included the use of very moderate steam pressures, the ideas of Perkins were considered as distinctly radical innovations. These included a flash steam boiler, generating steam at several hundred pounds per square inch, a steam gun, and especially a steam engine in which the steam flow was continuously in one direction, and in which metallic packing was provided on the piston to stand the high temperature at which the machine worked.

The steam gun has never been practically developed; the flash boiler has been revived and dropped out of sight; but the steam engine in which the steam is exhausted through passages uncovered by the piston at the end of the stroke, instead of being returned back behind the return stroke, has been developed into a practical machine of much promise. The engine of Perkins was made single-acting, and was of the vertical type. An enlargement in the diameter of the cylinder, at the end of the stroke, provided an annular opening communicating with a condenser, and the moment the piston passed this point the steam rushed past to the condenser, leaving only sufficient steam in the cylinder to provide for compression, and allowing the cylinder and lid but little time to cool, and a minimum of contact with exhaust steam. Perkins

built several engines of this type, some of them being compound, with cylinder ratios of eight to one, and operating at pressures up to one thousand pounds per square inch, but the possibilities of the system seem to have been overlooked until recently, although at the present time some excellent engines are being made upon the uniform flow principle. It is entirely possible that there are other good ideas in the work of the older engineers which are awaiting development, and one of the desirable features in the work of engineering societies might well be the examination of historical records with such an idea in view.

Operative Efficiencies

In considering the possible gains to be secured by the introduction of improved mechanical appliances it is well understood that the maximum practicable advantage to be secured should be critically examined, so that the real value of the change may be determined. It is not worth while to save a large proportion of cost in any particular operation if the total amount which may be saved forms but a small part of the entire undertaking; unless, indeed, the increased efficiency reacts upon a number of other elements with which it is connected in series.

It often follows, however, that the introduction of some new method of doing a thing brings with it such a number of indirect advantages that the original economy which stimulated the improvement becomes a minor incident in the development of the work.

Thus it has been maintained that the advantages accompanying any marked improvement in fuel economy in marine engines can be of little real value, because the steam engine, as improved for marine service, is already so efficient that the power cost in the engine room has already become a small element in the total operative cost of a vessel, and even if the fuel consumption were reduced one half it would affect the profit derived from the vessel to an unimportant degree. Admitting the truth of this contention, and it is a most important one to take into account, there are many other considerations which become of far greater value than the mere fuel economy to be attained by such a change, for example, as the substitution of liquid for solid fuel on shipboard.

It is a matter of demonstration that the thermal efficiency of an engine of the Diesel type is about double that of a steam engine, and while the cutting of the fuel consumption in two is not an enormous item in the operative cost, yet it is well worth consideration, especially in engining a new ship. Much more important are the advantages which appear in the details of operation of the floating power plant of which the machine forms only a portion. Thus, one of the most difficult manual operations required on a vessel at sea is that of stoking the furnaces of the boilers of a steamship, and the heavy character of the work and the absolute necessity for its continued maintenance, render the problem of stoking one which demands attention out of all proportion to the actual money value involved in the wages of the men or the cost of the fuel handled. With the substitution of liquid fuel for coal, the question of fuel handling is wholly settled, and a few pipes and pumps replace a body of men and a task which has been one of increasing difficulty ever since mechanical propulsion at sea has been used.

In addition to the handling of solid fuel at sea, the question of coaling a ship in port has been one of difficulty and inconvenience. Not only the conveying of the coal to the ship and the transfer from barge to bunkers have involved tedious, laborious operations, but the proper stowing of the fuel and the general dirtiness and confusion of the job have rendered it costly and troublesome. The use of liquid fuel replaces all this antiquated work by a simple operation of piping and directed flow, so that no operation is more

simple than the delivery of its fuel supply to an oil-propelled vessel direct through suitable pipe connections from convenient storage tanks.

While no enormous monetary saving may be expected because of the greatly increased efficiency of the oil-fed combustion engine over the steam engine, there are large advantages to be derived from the longer distance which may be covered before a given fuel supply is exhausted. In the case of countries which produce no liquid fuel within their own borders, it becomes practicable to take in sufficient fuel at the outward port to provide for the round trip, and there are few cruises which do not include some port at which a supply of liquid fuel may be obtained.

Not the least advantage of the oil engine over the steam engine for marine service lies in the space formerly occupied by steam boilers, and released for cargo on the oil-propelled vessel. Any examination of the plans of a steamship will reveal the large space allotted to the boilers, and when it is realized that engines of the Diesel type, for example, occupy little, if any more, space than is demanded by steam engines of equal power, it will be seen that the increase in transport capacity obtained by the removal of the boilers is a matter of distinct value.

When these secondary results of the installation of oil-fed combustion engines are considered, and the actual monetary savings which result are included in the total improvement in efficiency of the vessel as a whole are taken into account, it will be seen that there is much more than the bare fuel economy to be credited to the change. This is true of many modern improvements in mechanical appliances, and when any changes in motive power, in productive machinery, or in manufacturing processes are under examination, it is most desirable that both the secondary advantages and the secondary costs be taken into account and that a definite balance be struck between them in forming a critical opinion of the value of the change.

The Flow of People

There is probably no one problem in engineering which has demanded and received more attention than that involving the proportions and construction of channels and conduits for the conveying of fluids of various kinds from one point to another. For three hundred years and more the flow of water in channels and pipes has been studied, and every detail of surface friction, eddy resistance, internal work, and mean velocity has been examined theoretically and practically. In like manner the flow of air and of gases has been investigated, and it is practicable, with the information available and tabulated, for almost any engineer to compute the capacity of a given system of piping, or to plan a combination of channels to meet definite requirements. When several pipes are intended to deliver their contents into a main collector, the rules for proportioning the various sections are readily applied so that there shall be no undue obstruction to the flow, and the several velocities may be combined in a manner which permits the least practicable resistance to be imposed upon the movement of the entire mass.

These facts are so well known and so generally appreciated that any discussion of them in this place may seem so elementary as to be unnecessary, but it is the very completeness of our knowledge relating to the mechanical flow of inanimate substances which renders almost inexplicable the lack of practical application of the same principles to the flow of human individuals. A fluid is nothing more than an aggregation of molecules capable of a certain degree of mobility among themselves, and it will take a very moderate amount of observation of a mass of people to render it clear that such a crowd is subject to laws similar to those governing the motion of steam, water, or air. If a crowd of people approaching and passing through a narrow entrance be observed from above, it will be distinctly apparent that the flow of the human particles is almost identical in char-

acter with that, for example, of sand through the contraction of an hour glass. If such a crowd, while waiting, has a center of disturbance created within it, the concentric waves of agitated humanity will be perceived extending far beyond the cause of movement or beyond the direct knowledge of the human molecules.

Under such circumstances it is most curious that more attention has not been given to the laws governing the flow of people, in connection with the proportioning of streets, passages and various conduits through which the great currents of humanity are compelled to pass, and it is one of the educational problems of the immediate future to instruct engineers, architects and administrators in the important matter of the avoidance of artificial congestion, by providing rationally designed routes of travel.

At the present time there appears to be a surprisingly small amount of reliable information available upon the subject. How many architects know the capacity of a staircase, or the possibilities of a doorway, in terms of a definite flow of people in a given period of time?

What is the resistance of a certain contraction in a passage, or the frictional opposition of a sharp corner or a projecting buttress? Probably the builders of passenger elevators are in possession of experimental data concerning the capacity of such machines, but such information is sufficiently valuable to be kept for the use of those who have been wise enough to acquire it. These and similar points must soon become essential in the development of the city, the railway station, and the public building of any kind, and it is extremely probable that the greater the degree of fullness with which the information is secured, the closer the laws will be found to approximate those already ascertained for inanimate fluids.

One thing is evident, at least, the basic principle of efficiency in the movement of people, as with other things, will be found to lie in the maintenance of continuity of flow. Any interruption or any marked check to flow introduces such a degree of loss as to render it most undesirable, and in most instances a moderate average rate of flow, if uninterrupted, will provide a much greater capacity than an intermission of stoppages and spurts of high speed. The time is ripe for a study of the flow of people, and it is a problem of vast interest, both to the engineer, by whom it must be directed, and to the people themselves, who are even more closely concerned.

Equipment for the Future

There was probably no time in the history of the world in which the thoughts and efforts of men were so definitely extended forward than at the present. Nearly every department of industry is in a transition stage, and it is realized that a most important element in successful work is the maintenance of a keen and intelligent lookout, in order that the coming changes may be perceived in time to enable proper advantage to be taken.

It has been said that when any department of industrial activity shows evidence of having attained a high degree of efficiency it has probably reached a point where it will soon be wholly superseded by something entirely different. This has been true of the stage coach when the railway displaced it; it was true of the successive uses of wood, iron, and steel in shipbuilding; it was true when the fight between the *Merrimac* and the *Monitor* suddenly rendered all the wooden navies of the world obsolete.

Any examination of the introduction of the changes which have taken place in manufacturing will show the immense advantage obtained by the man who is early in the field, and it is one of the important things to be considered in the equipment of a great establiishment, since it is entirely possible to provide apparatus which is too good, too enduring, and too difficult to use up to advantage. It has been customary to assume a depreciation

charge of about ten per cent. a year upon machine tools, upon the assumption that such machinery should have its purchase price sunk in about ten years, but it is not so generally accepted that such machines ought, in very many cases, to be thrown out much earlier because of improvements in apparatus and methods which have grown up in the meantime.

This being the case, an important element in machine design should be the total probable productivity of the machine during its operative life, the problems of wear and tear being included in terms of its output. We have become accustomed to the determination of the amount of manual labour put into a manufactured product in terms of the so-called "labour cost," so that it is well understood that the labour cost of a product may be reduced by increasing the output in a given time, but it is customary to compute the machine cost by a rather arbitrary time rate for the tool, in which the various elements of power, depreciation, shop space and overhead charges are included. Possibly this latter method may be superseded by something similar to that already understood in connection with a piece of heavy ordnance, which is known to be capable of sustaining safely a definitely limited number of shots, and which must then be retired from service. The principal difference between the gun and the machine tool lies in the fact that the operative life of the gun, in terms of a definite number of rounds, is fairly well known, while the time when the machine has outlived its usefulness has yet to be determined.

Modern methods for computing the efficiency of workmen are based upon estimates of maximum efficiency determined by time studies made by experts, and hence are dependent to a certain extent upon the judgment and experience of the experts themselves, and are admittedly subject to modification, and yet even such efficiency determinations have enabled great advances to be made. It would appear that similar studies of the efficient life of the machine might well be made, not only in the light of actual productive capacity, but in connection with broad knowledge of what is being done in the laboratories of machine tool designers, and what is being discussed in the plans of inventors. This means the exercise of a far higher degree of foresight than is ordinarily demanded in present practice, but is no more than the actual conditions warrant. Many a manufacturing concern has been deterred from scrapping old equipment and installing later and more efficient tools by reason of unwillingness to discard tools which seem too good and too valuable to throw away; while the establishment which has already obtained full value from the old tools, and perceives the fact that they are clearly food for the scrap heap, is ready to take advantage of the immediate and effective opportunity.

THE TRANSMISSION OF HEAT INTO STEAM BOILERS

UNITED STATES BUREAU OF MINES

IN a recent Bulletin, issued by the Bureau of Mines of the Department of the Interior, and prepared by Messrs. Henry Kreisinger and Walter T. Ray, under the direction of Dr. Joseph A. Holmes, there are given the results of a number of important experimental investigations upon the transmission of heat into steam boilers. These experiments are of such value that every engineer who devotes his efforts to the improvement of apparatus for the generation of steam should consult them in their entirety, and the following abstract of the work will indicate both the lines along which the work has been done and the nature of the results obtained.

In Bryan Donkin's book, entitled "The Practical Physics of the Modern Steam Boiler," it is stated that James Watt obtained nearly as good an evaporation per pound of coal and per square foot of heating surface as is obtained now. The remark is probably true. At any rate, about the only decided superiority of the modern steam boilers over older types is in mechanical construction, and for this superiority credit should be given to the designers of machine tools quite as much as to the boiler engineer. The main reason for tardiness in boiler improvement probably lies in the reluctance of educated engineers to do the dirty and disagreeable work involved in boiler tests.

Nearly a hundred years of practical investigation of boiler and furnace problems has resulted in little advance. Perhaps the main reason why many of the investigations failed to bring about progress was that boiler and furnace were considered a unit and were investigated together. Various combinations of boilers and furnaces have been built and tested without thoughtful planning. Many of the published results of such tests confuse the performance of the boiler and the furnace in such a way that it is difficult, if not impossible, to tell which of the two should be blamed or praised for the poor or good results obtained from the combined apparatus. Evidently, many persons have thought that the combined efficiency could be greatly increased by some mysterious manipulation.

The principles governing the combustion of fuel in boiler furnaces and the absorption of heat by boilers have been little understood. The dogmas that the area of grate should have a certain ratio to the area of the heating surface, and that it takes 10 square feet of heating surface to make one boiler horse-power, seemingly had become so thoroughly fixed in the mind that they were hardly ever questioned. It is only within the last decade that a few engineers have broken away from the old rule of thumb methods and have begun to investigate the functions of the boiler and furnace separately. Their studies seem to mark the beginning of advance in steam-generating apparatus.

The boiler is the metallic vessel that contains water and steam and absorbs heat: consequently it should be studied as a heat absorber.

The furnace is that part of the steam-generating apparatus in which the potential energy of the coal is changed into heat; consequently it should be studied as a heat generator.

In almost all the boilers now used for generating steam only a small percentage of the heating surface is so

exposed to radiation from the fuel bed, furnace walls and flames as to receive heat both by radiation and convection. By far the greater part of the surface receives heat only by convection from the moving gaseous products of combustion.

The greatest resistance to the flow of heat is met before the hot gases reach the dry surface of the heating plate. If a boiler is even moderately clean, the resistance of the plate itself to the flow of heat through it is very small indeed. The resistance to the passage of the heat from the plate into the boiler water is also very small. It may be said that the heating plates transmit to the boiler water all the heat that can be imparted to their dry surfaces.

Increasing the rate at which heat is imparted to the dry surface of the heating plate increases the rate of steam production in the same proportion.

Since in most boilers the heat imparted by convection is the larger part of the total heat the boiler receives, increasing the rate at which heat is imparted to the heating surface by convection causes a nearly proportionate increase in the rate of steam production. If the initial temperature of the moving gases remains constant, increasing the velocity with which the latter pass over the heating plate increases in an almost direct ratio the rate at which heat is imparted to the dry surface of the plate, and therefore increases almost directly the rate at which steam is made.

In the future the velocity at which gases pass over the heating plates will be the factor that will be used for increasing the capacity of boilers. There is no valid reason why stationary boilers cannot be worked at two or three times the rate at which they are worked at present.

To increase the capacity of any boiler, pass more gases over its heating surfaces.

A boiler that has its heating plates arranged in such a way that the gas passages are long and of small cross section is more efficient than a boiler in which the gas passages are short and of large cross section.

If the same weights of gas at the same initial temperature are passed through a 2-inch and a 4-inch flue, both flues having the same length, the 2-inch flue will absorb more heat than the 4-inch flue, although the 4-inch flue has twice as much heating surface as the 2-inch flue.

Locomotive boilers are as a rule more efficient than stationary fire-tube boilers, because the tubes in the former boilers have a smaller diameter in comparison with their length than the tubes in the latter boilers.

To increase the efficiency of water-tube boilers, insert baffles in such a way that the heating surfaces are arranged in series with reference to the gas flow, thus making the gas passage longer.

As the velocity of gases over the heating plates of a boiler increases, the true boiler efficiency at first drops, and then, after the gases exceed a certain velocity, it remains nearly constant.

In multitubular boilers the true boiler efficiency increases as the diameter of the tubes decreases. In water-tube boilers the true boiler efficiency increases as the cross section of the gas passages between individual tubes decreases.

In multitubular boilers the true boiler efficiency increases as the length of the flues increases, and in water-tube boilers it increases as the length of the gas passages increases.

In boilers that receive the greater part of their heat by convection, the true boiler efficiency after the gases attain a certain velocity is nearly independent of the initial temperature of the gases.

Within certain limits, the true boiler efficiency depends on the shape of a boiler and not on its size nor its operation.

In the Bulletin there is given a resumé of a large number of experiments made upon small multitubular boilers, intended to determine the relations between the velocity of the air

to the absorption of heat, also the relation between the initial temperature and the rate of heat absorption, and the influence of heating surface, tube length and tube diameter. For the detailed data and results of this work the reader must be referred to the original report, but some interesting inferences may be mentioned here.

Thus, a study of the efficiency curves indicates that for any one boiler the true boiler efficiency, after the gases have passed the critical velocity, is very nearly the same for all initial temperatures, and hence the true boiler efficiency of any one boiler is practically independent of the initial temperature of the gases.

Again, a study of various arrangements and areas of flues leads to the conclusion that it is not area, but arrangement, that makes heating surface efficient. It does not pay to increase the length of flues beyond a reasonable limit, nor to increase diameter merely to gain area of heating surface.

Broadly, the following deductions may be made from the laboratory experiments detailed in the report:

When the temperature of the air entering a boiler remains constant, the rate of heat absorption by convection by the heating surface of the boiler flues increases very nearly in direct proportion to the velocity of the gas passing over the heating plate. This is particularly true beyond the point of the critical velocity.

When the velocity of the air remains constant, the rate of heat absorption increases as the initial temperature rises, but not in direct proportion to the rise; the increase in the rate of heat absorption becomes smaller for equal rises of initial temperature as the initial temperature increases.

With air velocities greater than the critical velocity the true boiler efficiency is nearly constant for any rate of working and for any initial temperature.

The critical velocity increases when the temperature rises, and seems to drop when the diameter of the flues increases.

Increasing the diameter of the flues decreases their efficiency as heat absorbers—that is, flues of large diameter are less efficient than flues of small diameter of the same length, although the large flues have more heating surface. The higher efficiency of small tubes is due to the fact that the average distance of each particle of the gas from the flue surface is shorter, and therefore each particle of gas comes oftener in contact with the surface. It is not the total area of the heating surface that determines the efficiency of a boiler, but the cross sectional area of the gas passage and the arrangement of the surface with respect to the flow of gas.

It seems that a large number of small flues having the same total cross-sectional area as a few flues of larger diameter require a smaller pressure drop to push the same weight of gas through than do the large flues.

Increasing the length of flues increases their efficiency, but not in direct proportion; the increase in efficiency becomes smaller with every successive addition to the length of the flue, so that to make flues larger than some definite length would not be good economy.

Most of the resistance to the passage of air through the flues of a tubular boiler is at the entrance to the tubes; adding to the length of the flues increases the resistance but little.

It has been sufficiently proven that the temperature of the gases on leaving a boiler varies almost directly as the temperature of the gases entering the boiler, both temperatures being reckoned above that of the boiler water; the lower the entering temperature the lower the leaving temperature. It is obvious that if two boilers have exactly a similar construction and baffling, the gases in the one which is so set that it receives more heat by radiation from the furnace will have the lower initial and final temperatures, and the efficiency of this boiler will be the higher. The gases themselves radiate but little heat to the boiler, but part of the heat gen-

erated by the combustion of the fuel is radiated by the hot fuel bed, the flames, and the furnace directly to the boiler, and is never absorbed by the gases. Therefore, the latter enter the boiler at a lower temperature than they would if they absorbed all the heat generated in the furnace. This means that any heat which the boiler gets directly by radiation is a clear gain. Of course the presumption is that the combustion and air supply is the same in all cases.

When fuel burns in a boiler furnace most of the heat generated is immediately absorbed by the gases that result from combustion. These gases then pass along the heating surface of the boiler and impart the heat they contain to the boiler; this heat impartation takes place almost entirely by convection. The gases then act as a conveyor of heat; that is, they carry the heat from the burning fuel to the "dry surface" of the boiler plate. Therefore the amount of heat a boiler receives per unit of time depends to a great extent on the utilization of the heat-conveying or convecting properties of the gases.

The conductivity of the metal forming the heating plate, even though the plate has a moderate amount of coating, is so high that any quantity of heat that can be imparted to the dry surface by convection can be transmitted through the heating plate without difficulty. Water has such high heat-abstracting ability that it can absorb heat as fast as the heating plate is able to conduct it. The slowness of the process of heat transmission into a boiler is due to the slowness with which heat, in present practice, is imparted to the dry surface.

It has been shown that the rate at which the gases transfer heat to the dry surface of the boiler depends on the following factors:

(*a*) On the difference of temperature between the gas and the dry surface.

(*b*) On the density of the gas.

(*c*) On the velocity at which the gas flows over the dry surface.

As to the first factor it must be said that boiler furnaces always should be operated at the most economical temperature. Generally this is not the highest practical temperature, as the necessary reduction of the air supply may cause part of the combustible to escape unburned from the furnace; further, a very high temperature may not be desirable on account of expensive repairs on the fire-brick lining in the furnace. Considering these two limitations the temperature should be as high as feasible in order to make the quantity of heat available as large as possible. In well-managed plants the furnaces are operated at the best economical temperature, and therefore there is not much chance of improvement by increasing the first factor.

The density depends on the absolute temperature of the gases, and is therefore fixed when the temperature is determined.

The velocity of gaseous products of combustion is independent of their temperature and their density and therefore can be increased at will whenever a higher rate of steam production is desired. It is this velocity factor which enables locomotive and marine boilers to produce steam at two or three times the rate customary with stationary boilers. In the first two types of boilers double or triple capacity is obtained by forcing over their heating surface two or three times the weight of gases at two or three times the velocity. The same results can be effected in stationary boilers; their capacity can be increased several times by forcing several times the weight of gases over their heating surface at several times the velocity.

It has also been shown, both by the results of experiments and by theoretical considerations, that more heat can be abstracted from the same weight of gas if the length of the gas passage is increased or the cross section of the passage is reduced; the second condition must always include the reduction of the "hydraulic mean depth" of the gas stream. Both of these conditions increase the number of contacts the

particles of gas make with the dry surface. With any given velocity, lengthening the gas path lengthens the time during which each particle can make contacts with the dry surface; reducing the cross section of all these "hydraulic mean depths" reduces the mean distance of each particle of gas from the dry surface of the plate so that the particle of gas can reach the surface in less time, and in the same available length of time make more contacts. Abstracting more heat from the gases means higher boiler efficiency. The length and the cross section of a gas path is really the arrangement of the heating surface with respect to the gas stream, so that one may say that the efficiency of the boiler depends on the arrangement of the heating surface with respect to the flow of gases.

The preceding deductions can be summarized in the following brief statements:

The capacity of a boiler can be increased by forcing a greater weight of gases through the boiler.

The efficiency of a boiler as a heat absorber can be increased by arranging the heating surfaces in such a way that the gas passages are long and of small cross section, so that they have a small "hydraulic mean depth."

The application of the principles of heat transmission offers an excellent opportunity for economic improvements in the steam-boiler as well as in steam-plant designs. It seems feasible to increase the capacity of boilers several times; and at the same time, by properly arranging the heating surfaces in the boilers, to raise the efficiency perhaps several per cent. Increasing the capacity of boilers would reduce the first cost of the installation, and consequently less interest would have to be paid on a smaller investment. Increasing the efficiency would reduce the coal bill. Under such conditions power could be produced much more cheaply than it is at present.

Considering the high heat conductivity of metals, there is no reason why boilers could not be made to generate steam at three or four times the rate they do at present by simply forcing about three or four times the weight of gases over their heating surfaces. This may be considered a conservative statement, as much higher rates are possible and have been attained.

It may at first seem that the power required to force such large quantities of gas through the boilers would be so great that the cost of installing and operating the "draft" appliance would offset any gain from the increased capacity of the boiler. However, such is not the case. It is true that the power required to push the gases through the boiler increases as the cube of the capacity the boiler develops, so that to triple the capacity of a boiler the power required to push the gases would have to be increased 3^3, or 27 fold; or, to quadruple the capacity the fan power would have to be 4^3, or 64 times as large as for single capacity. The one feature that makes high capacity possible is the fact that the power really consumed in ordinary cases in pushing the gases through the boiler and furnace is so small that even after it is multiplied by 64 it still remains only a small fraction of that developed in the boiler. Distrust in the possibility of working steam boilers harder rests on past experience. Engineers are accustomed to hear that the steam consumption in mechanical-draft appliances is from 1 to 2 per cent. of the total steam generated by the boilers which are served by the appliances. With such extravagant "draft" productions, of course large increase of boiler capacity would not be practicable. Thus, suppose that a fan producing "draft" for a boiler battery at ordinary rates of steaming consumes 2 per cent. of the steam generated in the battery. If the capacity is to be quadrupled, the fan would apparently have to do 4^3, or 64 times, as much work as before. Since 4 times the capacity is developed, the steam consumed would be $\frac{64 \times 2}{4} =$

32 per cent. of the total steam generated at the quadrupled capacity. This, of course, is a considerable percentage, high enough to make any commercial consideration out of question.

However, a little more detailed investigation will show that with present mechanical-draft outfits about 90 per cent. of the energy that can be developed from the steam consumed in the fan engine is wasted in the crude inefficient engine, in the still cruder fan, and in the long, leaky gas or air ducts having many sharp turns; and that only about 10 per cent. is actually expended in pushing the gases through the furnace and boiler. The power actually needed to force the gas through the boiler can be easily figured from the volume of gas to be displaced per minute and the pressure against which the gas must be moved. This power in foot-pounds is equal to the product of the pressure in pounds per square foot and the cubic feet of air displaced; the following expression gives it in horse-power:

$$\text{Horsepower} = \frac{\text{pressure (lbs. per sq. ft.)} \times \text{cu. ft. gas displaced per minute}}{33{,}000}$$

In specific cases the power expended in pushing gases from the ash pit to the base of the stack or to the uptake can be figured as shown in the following illustration:

Assume that in a battery of boilers ordinarily developing 1,000 boiler horse-power the equivalent evaporation is 9 pounds of water per pound of dry coal of average quality, and that it takes 15 pounds of air to burn 1 pound of dry coal; then the figures are:

$$\text{Weight of coal burned per minute} = \frac{1{,}000 \times 34.5}{9 \times 60} = 63.9 \text{ pounds.}$$

$$\text{Weight of air used per minute} = 63.9 \times 15 = 958.5 \text{ pounds.}$$

$$\text{Volume of air per minute} = 958.5 \times 13 = 12{,}460 \text{ cubic feet.}$$

Ordinarily the pressure drop from ash pit to uptake seldom exceeds 0.75 inch of water, but for convenience let the pressure drop in this case be taken as 1 inch. We then have, for the data in the case above given:

$$\text{One inch of water} = \frac{62}{12} = 5.16 \text{ lbs. per. sq. ft.}$$

$$\text{Horsepower} = \frac{12{,}460 \times 5.16}{33{,}000} = 1.95.$$

Now, according to the cube law, if the capacity of this battery is to be quadrupled the power needed to move the gases would be 4^3, or 64 times 1.95, which is approximately 125 horsepower.

Surely in a unit of this size one engine brake horse-power ought to be produced with one boiler horse-power, and fans having an efficiency of 75 per cent. can be built. With such outfits the consumption of steam for the quadruple capacity would then be

$$\frac{125}{4{,}000 \times .75} = 4.2\% \text{ of the total steam generated.}$$

When one considers that in big power stations power is produced in large electrical units at about half the steam consumption assumed above, and also remembers that the fans could be driven electrically, the quadruple capacity appears commercially very feasible—especially if by proper arrangement of the heating surfaces the efficiency of the boilers is increased.

If one considers the sizes of fans usually seen in power plants at present, he may perhaps make the objection that if the capacity of boilers were quadrupled the fans would be so large that they might take up the greater part of the space saved by making the boilers do more work. There is, however, no substantial reason for fearing such conditions. The fans used at present are unduly large because of their low efficiency: in different constructions the efficiency ranges from 80 down to 10 per cent., and in most is perhaps much closer to 10 than to 80 per cent. Fast-running fans of large capacity and high efficiency are now being put on the market. Such fans could be easily placed under or above the boiler they were to serve without being conspicuous on account of their size.

As an example of the feasibility of increased boiler capacity, the reader is

referred to United States Geological Survey Bulletin No. 403, wherein are described 21 tests made on a water-tube boiler of the United States torpedo boat *Biddle*. This particular boiler had a total heating surface of 2,776 square feet. It would, therefore, be rated in land practice as a 277.8 horse-power boiler. On some of the tests as much as 915 boiler horse-power were developed—about 3.3 times its rating in land practice—and still higher capacity was possible. A blowing fan forced the air directly into the fire room; the latter was as nearly air-tight as practicable and was kept under pressure. The wheel of the fan was 5 feet in diameter and 14 inches wide. It was placed directly on the fire-room wall and had no casing, but was protected by a wire screen. The blades were curved in the direction opposite to the rotation of the wheel. At the high boiler capacity mentioned the speed of the fan was about 850 revolutions per minute, and the power required was about 15 horse-power.

The question may be asked, Why are the fans used at present so crude and inefficient? The answer is that the manufacturer had to sell them cheaply in order to sell them at all, and cheapness and good design and efficiency in apparatus do not go together. Really, there was hardly anything to be gained by more refined and efficient mechanical-draft outfits. Suppose that the steam consumption would by refined apparatus be reduced from 2 per cent to ½ per cent. of the steam generated in the boiler, would any plant manager be willing to pay, say, double the price for the installation of a more efficient mechanical-draft apparatus to save at most 1½ per cent. of the steam?

Another objection that can be made to forcing steam boilers to high capacity is the alleged moisture in the steam. Here again one can refer to locomotive and torpedo-boat boilers; these types of boilers are working at about three times the rate customary in stationary boilers and work under conditions favorable to priming; still there is no particular trouble from moisture in steam. At large steam-turbine plants, where steam is highly superheated, complaints of higher moisture in steam are not heard.

In designing a steam-generating apparatus to produce steam at high rates, probably the greatest difficulties will be met in the furnace. To produce four times the weight of hot gas, four times the weight of coal must be burned in the same time. To burn coal thus rapidly without large losses through incomplete combustion of gases and tar vapors, driven off from the soft coals upon heating, and losses in sparks—losses which always accompany the high capacity of the locomotive and torpedo-boat boiler—the furnace would have to be the larger part of the steaming apparatus.

To prevent the escape of unburned gases and tar vapors, the principle of slow heating should be used in stoking the coal, in order to avoid the distillation of heavy hydrocarbons which are difficult to burn. Combustion space should be provided in which to burn the lighter and more quickly burning compounds.

In the locomotive and torpedo-boat boiler the grates are comparatively small, so that in order to force a large quantity of gases through the fuel bed the velocity of the gases must be high. This high velocity lifts small particles of burning coal from the fuel bed and carries them through the boiler. To avoid the loss from sparks in stationary boilers, the velocity of the gases through the fuel bed should be kept so low as not to start the sparks on their way to the stack. This end can be attained by increasing the grate area. The increase in the grate area will also reduce the resistance to the flow of the gases and thereby reduce the power needed to push the gases through the fuel bed. The velocity through the boiler itself should be high, so as to carry through the boiler any solid particles that might settle on the heating surface. If the gases flow faster through the boiler than through

the fuel bed, it is obvious that any solid substance that has been light enough to be lifted from the fuel bed will surely be carried through the boiler by the higher velocity. To burn four times the weight of coal on double the grate area would require much less pressure drop through the fuel bed than if it had to be done on the present small grates. Increasing the grate area would reduce the fan work considerably.

From the foregoing discussions it can be seen that the obstacles in the way of higher boiler capacities are superficial, and if the great advantage in the reduction of the first cost of a boiler plant is considered, it seems that the high-capacity boiler is bound to come in the near future. This reduction in boiler plant will give steam power a greater advantage over gas power in large central stations.

A few years ago the gas engine apparently threatened to displace the steam engine, and even the steam turbine, wherever mechanically feasible; that is, wherever real estate was cheap. It has not done so, however, and if one seeks the reason why it has not he has only to ponder some figures in a paper by William L. Abbott, chief operating engineer of the Commonwealth-Edison Company of Chicago.

Mr. Abbott states that of the total operating revenue received by large central-station companies, 50 per cent. goes out for "fixed charges," consisting of interest or dividends on investment, sinking fund, or depreciation, taxes, and insurance; 30 per cent. for operating expenses of all kinds whatsoever, and 20 per cent. for general expenses, including salaries of general officers, advertising, rentals, etc. Of the 30 per cent. spent for operating expenses, 20 per cent. goes for coal; in other words, only 6 per cent. of the company's gross operating income goes for fuel.

Mr. Abbott specifically states that the fuel saving attained by a gas-engine plant would be more than overcome by the heavier fixed charges on such a plant; especially would this hold if the heavier labour costs in gas-engine plants using producers are taken into consideration. Now, it is easy to see that a gas-engine plant that would save half the coal (an improbable attainment) would save only 3 per cent. of the gross operating revenue, and that the increased labour costs alone might approach the saving, not to consider the added bond interest.

The following figures of the cost of installation of steam-turbine plants and of producer-gas engine plants of large capacities are taken from a chart compiled by Edwin D. Dreyfus:

COST OF INSTALLATION OF STEAM-TURBINE AND OF PRODUCER-GAS ENGINE PLANTS.

Total plant capacity installed.	Cost of steam-turbine plant per kilowatt.	Cost of producer-gas engine plant per kilowatt.
Kilowatts.	*Dollars*	*Dollars.*
4,000	75	110.00
8,000	65	104.00
12,000	58	102.00
16,000	53	100.00
20,000	49	99.00
24,000	47	99.50
28,000	46	98.30

The cost of labour Dreyfus gives as 19 to 13 per cent. of the total power-plant charge in the steam plant and from 23 to 20 per cent. in the gas-producer plant.

The above status of the comparison is present day. It has been repeatedly pointed out in this bulletin that there are bright prospects of getting two or three and perhaps four times the amount of steam from a given boiler-house investment at a higher efficiency than is usual at present. If steam power-house builders should put as much extra money into air preheaters, fans, economizers, etc., as the advocates of gas engines desire put into gas installations, the additional equipment would work some surprises; whether the greater investment would be sound commercial economy in most cases the authors of this bulletin do not undertake to say.

It is well known that in modern turbine power plants the boiler room is the costly portion; if it be assumed (probably safely for our purpose) that only one-fourth of an electricity supply company's money is in its

power houses, and that three-fifths of this latter investment is in the boiler rooms, then to reduce the boiler-room investment only one-half would reduce the total bond interest 7.5 per cent., a liberal dividend on the average amount of capital stock—and it must be borne in mind that such companies always will be run for the benefit of the stockholders.

The reader will surmise by this time that the imminence of new competition was the best thing that ever happened to steam engineering; it is altogether possible that the rapid strides now being made in boiler-turbine plants will keep them commercially in advance of gas installations, so far as one can now see, except in those cases where gas is to be had for next to nothing or as a by-product.

By applying the principles of heat transmission developed in the general discussion it would be possible to design with fair accuracy a boiler for any desired efficiency. It has been shown that the efficiency of a boiler can be increased by increasing the length of gas path or by reducing the cross section of the gas passages. By the latter is meant the cross section of each elementary stream and not the sum of all of them, as, for example, in the locomotive boiler it is the cross section or the size of the tubes which determines the efficiency and not the number of tubes. In other words, the reduction of cross section must reduce the "hydraulic mean depth" if the efficiency is to be increased. The "hydraulic mean depth" is the quotient of the area of the cross section of the gas stream divided by the perimeter formed by the heating surface of the boiler and touched by the gases. Thus, if the size of the tubes in fire-tube boilers is reduced, the area is decreased in proportion to the square of the diameter of the tubes, whereas the perimeter is reduced only in proportion to the first power of the diameter; therefore the quotient, or the hydraulic mean depth decreases in proportion to the diameter of the tube. If, however, the size of tubes is kept the same but their number is reduced, then the area decreases at the same rate as the perimeter, and therefore the "hydraulic mean depth" remains constant.

In a similar way the effective reduction in the cross section of the gas stream in a water-tube boiler is attained only by placing the water tubes closer together and not by reducing the number of tubes or baffling the boiler. So that to be effective a reduction in cross section of the gas stream must always be accompanied by a reduction of "hydraulic mean depth," or the mean distance of the particles of gas from the dry surface. The last expression will perhaps appeal best to the reader inasmuch as the reasoning back of it is a little plainer—the closer the gas particles are to the dry surface the more contacts they can make with it in a unit of time. The reasoning for a long gas path is that the longer the path the longer the time for the gas to pass over the heating plate and the more contacts the gas particles make with the dry surface.

At present there is no boiler designing based on the principles of heat transmission. The various important relations are merely guessed at, and the boiler builder sells his boilers with guaranteed efficiencies which he is never sure can be realized. As a result of this guesswork, one often comes across results of commercial tests that could not be duplicated and would not stand a close examination.

It may be objected that tubes of small diameter will become choked with soot and cinders. This objection was probably first made by the builder of the stationary fire-tube boiler; still the locomotive boiler builder in the attempt to increase the heating surface used tubes of half the diameter commonly found in stationary boilers; the proof that this reduction of tube diameter was "practical" and that there is no serious trouble from the choking of the small tubes is that thousands of locomotives are in use. Furthermore, the flues of well-kept boilers are cleaned in some plants every day, so

that there is little chance for them to get choked.

What has been suggested for the fire-tube boiler can be applied equally well to water-tube boilers. Here, too, the principles of heat transmission can be applied to increase the efficiency. To quicken the rate of heat flow from the gas to the dry surface bring the gas close to the metal by reducing the gas spaces between the tubes through the use of smaller tubes placed closer together; in other words, reduce the "hydraulic mean depth" of the gas passages. For the parallel-flow type of boiler the relation between the efficiency and the "hydraulic mean depth" is probably the same as for fire-tube boilers. An exact determination of this relation would certainly be of great value to the steam-engineering industries. In the cross-flow types of boiler the relation would very likely be complicated by an extra factor, the eddying caused by the expansion and contraction of the gases.

In general, it can be said for all boilers that whatever increases the ratio of the length of the gas path to the "hydraulic mean depth" of the cross section of the path, increases the efficiency of the boiler. This ratio can be increased either by increasing the length of the gas path or by reducing the "hydraulic mean depth."

The length of the gas path can be increased either by increasing the length of the boiler, or by baffling in such a way that the gases will pass successively through different parts of the boiler; in other words, by putting parts of the heating surface in series with one another.

In the water-tube type of boiler, the use of tubes of small diameter would tend to increase the work of cleaning the boiler internally. In plants having condensers this objection would not be serious, and in small plants without condensers the scale-forming ingredients could be chemically precipitated and removed from the water before feeding it into the boiler.

The application of some features of the laws of heat transmission, deduced from the experimental work of the technologic branch of the United States Geologic Survey and the investigations of others, to steam boilers already installed is considered here. It is not practicable in the case of an existing plant to take advantage of all the improvements that the principles of heat transmission suggest. For example, it is unpractical to replace a small number of large flues in a multitubular boiler by a large number of small ones, or to exchange the large tubes of water-tube boilers for a larger number of small tubes placed very close together; in other words, it is not feasible to increase the efficiency of such boilers as heat absorbers by decreasing the "hydraulic mean depth" of the gas passage. On the other hand, it is possible to increase the output of a boiler already installed, by pushing through it a larger quantity of gases; or, it is possible to increase its efficiency by inserting baffles in such a way as to put parts of the boiler's heating surface in series.

It is interesting to note that some of the points thus developed by this valuable series of experiments by the engineers of the Bureau of Mines were anticipated by the researches of the Swedish engineer, F. Almgren, many years ago. Quoting the investigations of Geoffroy, Almgren stated that the amount of steam produced by tubular heating surfaces depended upon the volume of heated gases passing through the tubes per hour. From experiments made upon a locomotive boiler, he deduced the advantages obtainable by increasing the velocity of the hot gases through the tubes, and showed the relations existing between the velocity and length of tubes for maximum efficiency.

Now that the subject has been given a critical discussion, in connection with additional experiments, it is probable that the whole subject of the design of tubular boilers, especially for locomotive and marine service, will be advanced by reason of the rational basis upon which the whole subject has been placed.

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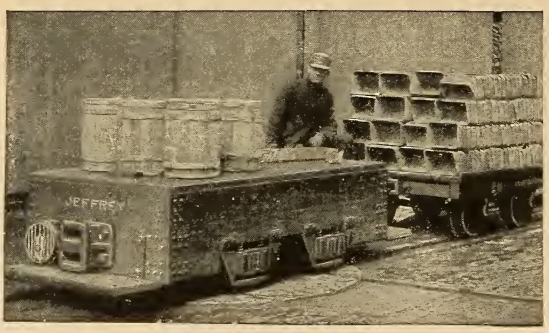

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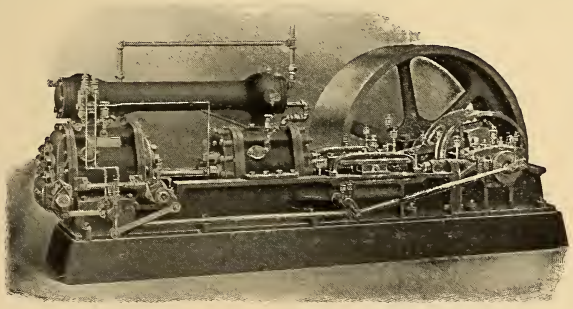

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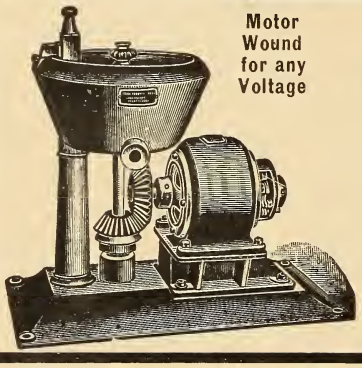

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The fact that the present development of the Westinghouse Electric and Manufacturing Company is so largely the result of the indefatigable work of the men by whom it was established, lends especial interest to their later connection with its successful progress. For this reason the career of Mr. J. McA. Duncan, whose portrait we give in this number, is worthy of particular notice. Mr. Duncan was one of the original group of eight men taken from the Union Switch & Signal Company twenty-five years ago to form the Electric Company, the works then being situated on Garrison Alley, Pittsburg. He was first connected with the shipping department and subsequently placed in charge of the correspondence department, involving the railway and lighting apparatus of the rapidly-growing concern. After a comparatively brief stay in the New York office of the company, Mr. Duncan returned to East Pittsburg, and, passing through the office of director of costs, he became assistant manager of works, in charge of production and costs. With the increased activity of the company he devoted himself to the department of works accounting, and he has now been appointed district manager of the Westinghouse Electric and Manufacturing Company, this position covering the Pittsburg district, one of the most important of the offices maintained by the Electric Company.

J. McA. DUNCAN

Westinghouse Electric & Manufacturing Company

See reverse side

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AN ENGINEERING MONTHLY

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THE SPEED LIMITATIONS OF AIR TRAVEL

SOME LESSONS FROM THE INTERNATIONAL CUP RACING AT CHICAGO

By R. Emerson

ON the morning of September 9, 1912, a small crowd, consisting of fewer than one thousand people, saw the accomplishment of a feat which will not be duplicated in America for another year, and which sets a new mark in the effort to abridge distance. Never before has a man traveled so fast, for so long, as did Jules Vedrines, the air-speed champion of the world, on his little 14-cylinder, 140 horsepower Gnome-engined monoplane, built by Armand Deperdussin, after an expenditure of $600,000 in experimentation.

A hexagonal course was covered thirty times, giving a total distance of 200 kilometres, or 124.3 miles, in 70 minutes and 56.85 seconds, or at an average speed of a little more than 105 miles per hour. As a matter of fact, a careful observation, on the ground, of the distance covered by the machine, including the wide clearances given the pylons, gave a speed within a mile of 110 miles per hour. This may well be compared with the speed of 108 miles, as measured by chronometer, for the fastest lap made by Vedrines around the 4.14-mile (6⅔-kilometre) course. Allowing for loss of speed due to the turns, and to a variable cross wind, this most recent air racer is probably capable of a maximum speed of about 115 miles per hour. If equipped with a still smaller pair of wings—which Vedrines did not risk using, because competition did not compel him to do so—the speed would be still higher. Vedrines claims 200 kilometres, or 124.3 miles; but it appears that 120 miles per hour, under ideal flying conditions, is more nearly the outside limit.

The question which is asked today, by the public, by engineers and by those in the inner circles of aviation performance and aerodynamic science, is:

"How fast will men be able to fly next year; five years from now;—1950?"

"What are the limitations? Are these limitations to be found in the strain on human pilots; in the speed with which a plane can leave the ground; in the design of surfaces and body, or in the propeller speed?"

Some of the points may be answered at once; others, however, are not yet matters concerning which sufficient information is available.

Aside from the skill required in

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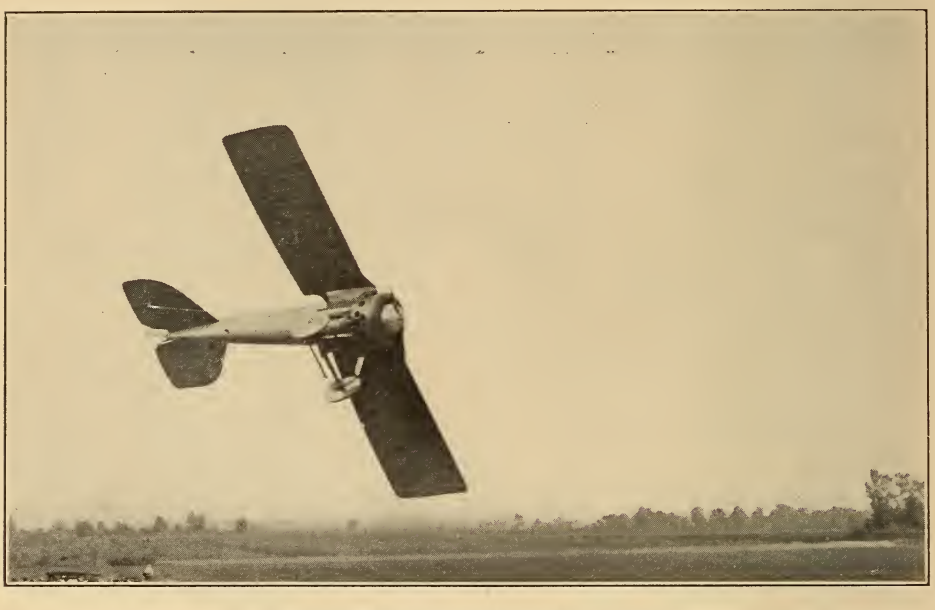
leaving the ground, in landing, in banking at turns, and in being alert to unexpected gusts of wind, flying at high speed, in a properly designed machine, has proved to be easier than flying slowly. The rush of wind, mixed with the exhaust from the motor, does not touch the aviator, who sits comfortably in a dead air pocket, while maintaining a good view of his course. Vedrines did not even use goggles during his



THE DEPERDUSSIN SPEED AEROPLANE IN ACTION

fastest flying, and he told the writer that, even with the considerable cross-breeze with which he had to contend, he was able to manipulate the controls by a touch of his fingers. The limit of high speed is not yet to be found in the man at the wheel.

At the present time the swiftest racers leave the ground at a speed of more than 80 miles an hour. Now, since an automobile driven on a hard beach has attained a speed of 140 miles an hour, and as there is no reason to doubt that a solid and level mono-starting rail or platform could be built permitting starting speeds as high as 200 to 300 miles per hour, we must look elsewhere than in starting and landing in our investigation of speed limitations.

The largest and lightest (per horse-power) commercial aeronautic motor yet built is the 160 horse-power, 14-cylinder Gnome motor, which has a weight of 475 pounds, complete, or about 3 pounds per horse-power. The bore and stroke of its cylinders are 124 and 140 millimetres, respectively (4 15/16 by 5½ inches), which is nearly the limit of cooling capacity for air-cooled cylinders. If there are limits to the size of air-cooled cylinders, there seems to be no good reason why several motors might not be used together—and there are some very good reasons why such an arrangement should be made. As a horse-power has carried more than 30 pounds, at moderate speeds, in an efficient aeroplane, and as the "Monocoque," as the Deperdussin racer type is called, has carried about 15 pounds per effective horse-power at its highest speeds, there is, it will be noted, a large margin for the effective application

of power to a high-speed aeroplane.

Fuel and oil consumption, however, are important factors in this speed problem, and these place very definite limits upon the duration of time in which a machine may remain in the air without landing. Were it not for these limitations, it would be a simple matter to improve the record made by Fourny, who, a short time ago, in a Farman biplane, traversed 659 miles in a little more than thirteen hours without landing. Traveling across country, or over water, with a fair wind of 30 miles an hour and an average speed of only 100 miles per hour for the machine (due to the weight of fuel carried), a distance of 1,700 miles could be covered without stop, or practically across the Atlantic from Newfoundland to Ireland.

If sufficient carrying surface is provided (and it can be shown that loads of 10 to 20 pounds per square foot of supporting plane can be carried, depending upon horse-power, speed and angle of incidence), it is manifestly possible to provide 500 to 1,000 horse-power in a single aeroplane, under the control of one or two men, as has already been done in motor boats. The possible gain in speed, due to the increased application of power, and the slightly greater weight and size of the aeroplane furnish an interesting problem.

We have the old formula:

$$R = K S V^2 \qquad (1)$$

That is: Resistance (to progression through the air) equals the product of a constant (depending upon the size and shape of the supporting surface and adjuncts thereto), the area of the supporting surfaces, and the square of the velocity.

It will be interesting to apply this formula to machines of 100 horse-power and 140-horse-power for purposes of comparison, assuming equal surfaces and the same constant.

We have the two formulas:

$$R_{100} = K\ S\ V^2_{100} \qquad (2)$$

$$R_{140} = K\ S\ V^2_{140} \qquad (3)$$

Assume

$$R_{100} = 100$$
$$R_{140} = 140$$
$$K = 1$$
$$S = 1$$

V is equivalent to 100 miles per hour, V_{100} being unknown.

Substituting in (2) and (3) the known values, we have:

$$V^2_{100} = 100 \qquad (4)$$
$$V^2_{140} = 140 \qquad (5)$$

Then:

$$V_{100} = 10 \qquad (6)$$

and

$$V_{140} = 11.8 \qquad (7)$$

But V_{140} is equivalent to 110 miles per hour; therefore,

$$V_{140} : V_{100} = 110 : x \qquad (8)$$

$$\frac{11.8}{10} = \frac{110}{x} \qquad (9)$$

$$x = \frac{110}{1.18} = 93 \text{ miles per hour} \qquad (10)$$

The significance of these figures is that, if we had two aeroplanes, identical in all respects (including weight and skill of pilot), except in power of motor, and the one equipped with a motor of 140 horse-power could make a speed of 110 miles per hour, then the sister-plane, with only a 100 horse-power motor, could make a speed of only 93 miles.

Now, almost this very condition prevailed at the Chicago races. Vedrines had a machine equipped with a motor of 140 horse-power. Prévost had a machine, nearly identical in construction and dimensions, practically the only difference being the fact that his motor was of 100 horse-power. The more powerful machine, therefore, had to carry about 100 pounds more weight. Vedrines actually made a speed of 108 miles per hour under the same air conditions in which Prévost, by a closer clipping of the pylons, made 105 miles. Since Prévost made his best time in the early part of his flight, when laden with a full charge of fuel, and as the record of Vedrines

was made in a speed test, with his fuel tanks nearly empty, the 140 horse-power machine was probably the lighter of the two.

Reduced to the straightaway flight in still air, the respective maximum speeds, within a mile, were:

Védrines, 140 H. P., 110 miles per hour;

Prévost, 100 H. P., 106 miles per hour;

or an increase of 4 per cent. in speed for an increase of 40 per cent. in power.

In other words, Prévost, with a machine of 100 horse-power, obtained a speed of 13 miles, or 14 per cent. in excess of that called for by the formula.

The natural conclusion is either that the formula must be imperfect or that the motors did not develop the powers with which they were credited, or that some other unconsidered factor entered into the problem. Since no other disturbing factor is known, it is desirable to examine the matter of the actual power of the motors.

It is reported that the 140 horse-power Gnome motor gives actually only about 80 per cent. of its rated power, while the 100 horse-power Gnome is said to give its full rating. Assuming this to be the case, we then perceive that a 4 per cent. increase in speed has been obtained by an expenditure of 12 per cent. increase in power.

Revising our formulas, we have:

$$R_{100} = K\ S\ V^2_{100} \qquad (11)$$

$$R_{112} = K\ S\ V^2_{112} \qquad (12)$$

$$V_{100} = 10 \qquad (13)$$

$$V_{112} = 12.6 \qquad (14)$$

If V_{112} is equivalent to 110 miles per hour, then:

$$V_{112} : V_{100} = 110 : x \qquad (15)$$

$$x = \frac{110}{1.06} = 104 \text{ nearly} \qquad (16)$$

This is a result much closer to the observed 106 miles made by Prévost, and seems to confirm the reported actual power of the 140 horse-power motor. At the same efficiency, the 160 horse-power motor, allowing for no increase in weight, would give 119 miles per hour.

If, now, we consider a motor of 1,000 horse-power, the formula for the speed of the machine would be:

$$V^2_{112} : V^2_{1000} = 110 : x \qquad (17)$$

$$\frac{10.6}{31.7} = \frac{110}{x} \qquad (18)$$

$$x = \frac{110 \times 31.7}{10.6} = 320 \text{ nearly} \qquad (19)$$

But the motor of 1,000 horse-power would weigh from 1,500 to 2,000 pounds more than the 140 horse-power motor, requiring, however, very little more supporting surface than the 110-mile machine, owing to the greater carrying power of the higher speed planes. But, as we have no factor in our formula for load per unit of supporting surface, we may substitute the increase in surface required for carrying a heavier motor at the same unit load, or about two and one-half times.

We then have, assuming K as unity, for similar designs:

$$R_{112} = S_1 V^2_{112} \qquad (20)$$

$$R_{1000} = S_{2.5} V_{112} \qquad (21)$$

$$V^2_{112} = \frac{R}{S} = 112 \qquad (22)$$

V being equivalent to 110 miles per hour.

$$V^2_{1000} = \frac{R_{1000}}{S_{2.5}} = 400 \qquad (23)$$

$$\sqrt{112} : \sqrt{400} = 110 : x \qquad (24)$$

$$x = \frac{110\sqrt{400}}{\sqrt{112}} = 208 \text{ nearly} \qquad (25)$$

We, therefore, have about 200 miles per hour as an approximate speed limitation with any motor in sight, applied to a machine of ordinary size. Furthermore, it does not appear that any great increase in

VEDRINES IN THE DEPERDUSSIN AEROPLANE. SPEED 110 MILES AN HOUR

size will permit of the installation of a power plant capable of pushing its greater size through the air at a speed faster than that attained by a smaller machine with its maximum power plant.

The racing Deperdussin "Monocoque," fully charged for a maximum flight, weighs about half as much as the burden-carrying types of Blériot, Sommer and Farman machines.

Is present practice with regard to wing sections and body designs susceptible of much improvement, so that at very high speeds no serious impedance may take place, or that with present power application somewhat higher speeds may be attained?

As an illustration of what may be done in this direction, a comparison of performances of the Deperdussin and the Hanriot machines will be of interest. These monoplanes, each equipped with a 100 horse-power Gnome motor, and of substantially the same size, weight and spread of surface, were piloted respectively by Prévost and Frey in the cup race at Chicago. The Deperdussin had a whale or porpoise-shaped body and almost flat, knife-edge wings; the Hanriot had a fusiform body of rectangular section, instead of oval, and neither the tail nor the planes conformed so closely to the streamline form. The wings were similar to the Nieuport in section, being thick and blunt. The rectangular fuselage sets up air eddies along the edges, not found in bodies with rounded section. The chassis, or landing wheels and struts, of both machines were very simply designed, and appeared of equal efficiency.

The fastest lap made by each of these machines was as follows: Deperdussin, 100 H. P. Gnome, 106 miles per hour; Hanriot, 100 H. P. Gnome, 94 miles per hour—an increase of nearly 13 per cent. in speed, due to the finer lines in body and surfaces.

Is further refinement possible? Undoubtedly. Taking the 140 horse-power Deperdussin as our example, several avoidable factors of resistance to progress through the air at a high velocity are apparent. In the first place, the chassis, struts and wheels, for all the simplicity of their design, offer considerable resistance. This may be diminished in some way, just as the birds fold their legs and feet back against their under surfaces. While nothing was seen at Chicago of that French aviator who, it was reported, was going to drop his wheels, etc., behind him when once he had launched himself into the air, in order to be free of that incumbrance (trusting to Providence to spare his life in landing), there is no reason why a collapsible chassis might not be used. The chassis might also be wholly enclosed within the body of the machines, as in the "Bullet," built by Gallaudet. If the machine rises from the surface of the water, the body might be made to serve also as the hydroplane pontoon, dispensing with auxiliary water surfaces for rising and alighting, as has been done in Loening's aero-boat and in the latest water biplanes of Curtiss and Donnet-Leveque.

Placing the propeller at the stern or tail instead of at the stem should improve the efficiency, because the disturbed air would then not be driven back against the body and supporting surfaces of the machine. This arrangement was adopted with conspicuous power economy at high speeds in the Paulhan-Tatin monoplane, and the difficulties in steering that type should be overcome. Power boats and ships of to-day are driven by stern propellers, and are steered readily enough. Gallaudet adopted the same arrangement. Incidentally, the nose of the body may be so designed as to part the air in the most efficient manner, as this is an important factor in the subsequent undulations and the friction of the air streams as they flow past the body surfaces.

Lastly, the wings, instead of being substantially rectangular in plan, may be sloped back, as they extend out-

ward, like the German "Swallow" and "Pigeon" types of machines. After the publication of Eiffel's present experiments on the resistances of different fuselages and wing forms, we may have a more exact knowledge of the increased speed capabilities of such a wing design.

Nevertheless, it seems as if little improvement in speed is to be anticipated over the performances of the latest Desperdussin machine. The writer stood under one of these machines as it roared past but six or eight feet above his head. He expected a great rush of air. After the machine had passed and was several hundred feet away, he felt the faintest zephyrs. But for the pungent odour of charred castor oil, and the roadring drone of the motor, with its sharply varying tone pitch as it approached and receded, the presence of the machine would not have been suspected. Such a lack of "wake" or "wash" denotes extraordinary efficiency of the surfaces and body. It is estimated that an increase of 10 or 15 per cent. in speed is the utmost which may be expected in consequence of refinement in the design of these features, thus making about 135 miles per hour the practicable limit with a motor of 140 nominal horse-power.

The remaining limitation to the speed of the aeroplane to be considered is that of propeller efficiency.

The "Monocoque" of Vedrines was equipped with an "integrale" propeller by Chauvière, operating at a speed of 1,200 revolutions per minute. This propeller was a trifle more than 7 feet 8½ inches in diameter, with a pitch of 10 feet 4 inches, giving a peripheral velocity of about 29,000 feet per minute. Such a peripheral velocity leaves almost no factor of safety, so that there is no room for the use of greater rates of revolution. Any material increase in pitch would also result in a loss in propeller efficiency which could not be offset by increased motor plant. Those who have specialized in air-propeller design place the limit of speed, under present known conditions, at about 150 miles per hour; and while 200 miles per hour have been suggested by some as a possibility, the means by which this may be realized are not indicated by our present engineering practice and knowledge.

For speeds in excess of 200 miles an hour, some other means of propulsion than the screw propeller must be found, and possibly the reaction jet may be again considered. While the velocity of gas-flow may attain figures far beyond our ability to employ them for the propulsion of air craft for many years to come, the limitation to the use of this method lies rather in the enormous fuel consumption which it involves. It has been computed that an aeroplane driven upon this principle could remain in the air but a few minutes, so that it seems improbable that we shall have a "rocket of the air" as the precursor of high-speed air travel.

Due to the endurance and strength of the pilot, no apparent limit exists; due to possible improvements in landing arangements, speeds of 200 to 300 miles per hour seem practicable; motor limitations seem to point to about 200 miles per hour; propeller speeds give limits of 150 to 200 miles per hour; while the influences of the shape of planes and body will permit the attainment of projectile speeds.

The problem is squarely up to the means of propulsion—at present the propeller.

We shall hardly reach 120 miles per hour this year; shall not reach 150 miles for another two or three years; and it is very doubtful if a speed of 200 miles per hour will be reached within ten years.

It is almost certain that these topmost speeds will be without commercial utility, though they may be of occasional value in military operations. Such flights must necessarily be of brief duration, owing to the amount of fuel that must be carried.

ASBESTOS

ITS PRODUCTION AND INDUSTRIAL APPLICATIONS

By J. F. Springer

There are many substances which, while not ranking among the staple mineral products, are yet of much importance and value, and yet about which comparatively little is generally known. Thus, asbestos has a number of useful applications in the arts and forms the basis of important industries, but to many persons it is merely a curiosity, of which specimens may be seen in mineralogical cabinets, and from which some commercial products are made The following article may, therefore, be found acceptable as indicating something of the methods of obtaining the raw material and of the extent to which its practical applications have been developed.—The Editor.

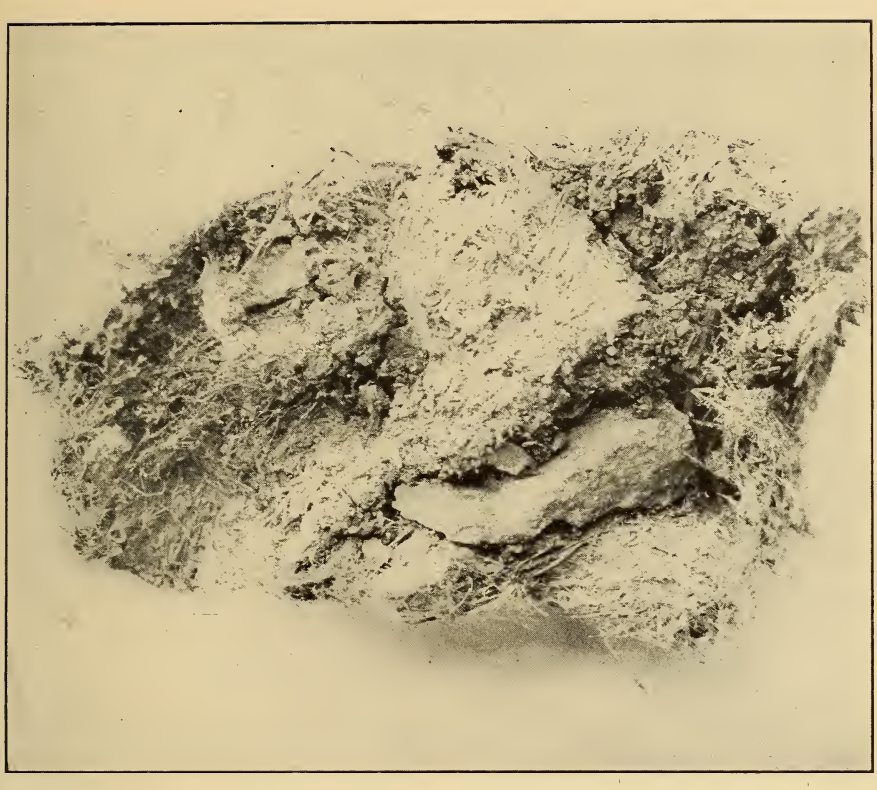
ONE of the most important properties of asbestos is its ability to resist the action of fire. Or, to put the matter in a somewhat different form—asbestos is highly prized because at high temperatures it still resists the action of the free oxygen in the atmosphere. Perhaps few of us stop to consider why this is the case, but when we have realized the significance of what the mineralogist and the chemist have to tell us we see very clearly how the case stands. Asbestos will not burn or combine with oxygen, because it is already burnt. A typical piece of asbestos consists principally of alumina, silica, magnesia and ferrons oxide. Every one of these is an oxide. So much for what the mineralogist has to say. The chemist tells us, however, that all these substances are themselves oxides. That is, oxygen has already entered into the combination. Asbestos will not burn, then, because the appetite for oxygen has already been sated.

Asbestos has also the property of furnishing good resistance to chemical action. Because of this it is quite useful in certain industrial operations. In fact, asbestos is regarded as one of the oldest forms of matter on the earth. For countless ages it has withstood the destructive agencies of nature. Tested thus in her laboratory, it is ready for man's use. And he finds this indestructible material of wonderful assistance in the industrial world.

Asbestos is, perhaps, finding its chief application largely because of still another quality. It is a very poor conductor of heat. The combination of the qualities of a heat insulator and of an incombustible material renders this material an especially advantageous covering for steam piping, furnaces, and the like.

None of these qualities would probably have created much interest in the industrial world, however, if asbestos had remained, as it once was, a highly expensive material.

The Italian asbestos was, and probably is, the finest article. This variety can be obtained in the form of long fibers, and is the material termed *amianthus*. It has been known for a great many years. Pliny perhaps thought asbestos was of vegetable origin, since he used the name *linum vivum*. He mentions the shortness of the fiber. This is difficult to understand, as it is thought that he must have meant amianthus. Even in those days asbestos was woven into cloth. It is not certainly known just how this was done—perhaps, though, some vegetable fibre was intermingled with it, and the weaving accomplished with its aid. There was a winding sheet of amianthus in the Vatican library, soft and pliable in the hand, and showing indications of ignition upon one cor-

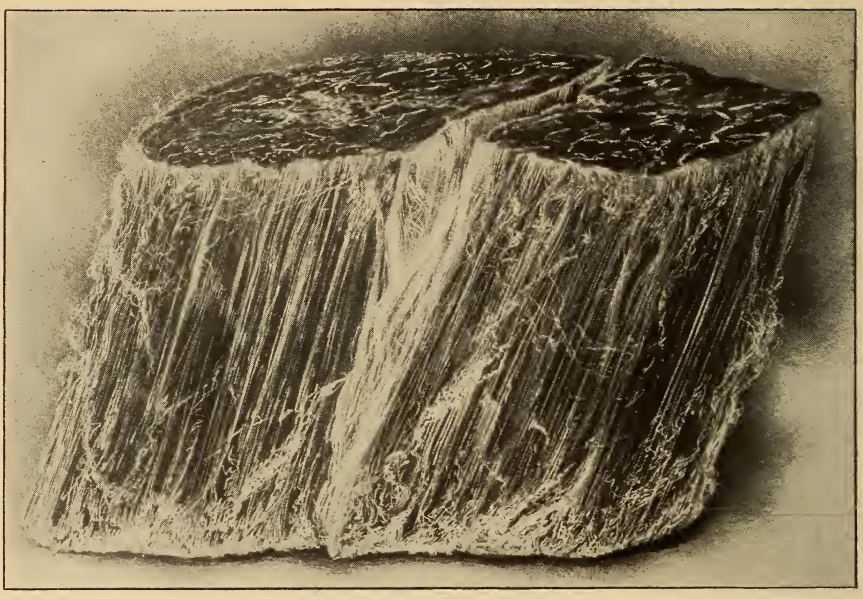


TYPICAL ASBESTOS CONGLOMERATE FOUND IN THE URALS, CONTAINING CLAY, ROCK, GRAVEL, AND ROOTS

ner. The cloth, however, did not suffer. This burning is taken as showing that some combustible fibre had been intermingled. Marco Polo, in the thirteenth century, reported a cloth which the natives of territory now included in Russian Siberia claimed as having been made of salamander skin. Marco Polo satisfied himself, so it seems, that he had to do with a mineral substance. In fact, he found out something as to its manufacture. In this same general region of country asbestos is to-day known to exist.

We are not to regard asbestos as a single, definite mineral. Nor are we to understand that there is a fixed chemical constitution. Certain forms of hornblende and serpentine, if fibrous, are regarded as asbestos.

Nearly all the asbestos of commerce comes from Canada. Perhaps the chief distinguishing feature from the point of view of composition as between the Italian and the Canadian varieties is to be found in the fact that the former is said to be anhydrous. However, the Canadian mineral controls the industrial situation. As far back as the middle of the last century asbestos was known to exist in Canada. But little attention was attracted, probably because of a non-commercial size of the deposits. A farmer, Fecteau, discovered in 1877 the mineral in commercial quantities, and almost immediately production became valuable. In 1890 the total value extended a million and a quarter dollars. This value of output has never been equaled since, unless the exception has occurred in the last year or so. The weight of asbestos produced in 1890 was 9,860 tons, having an average value of nearly $128 per ton. The value per ton has pretty steadily declined since.



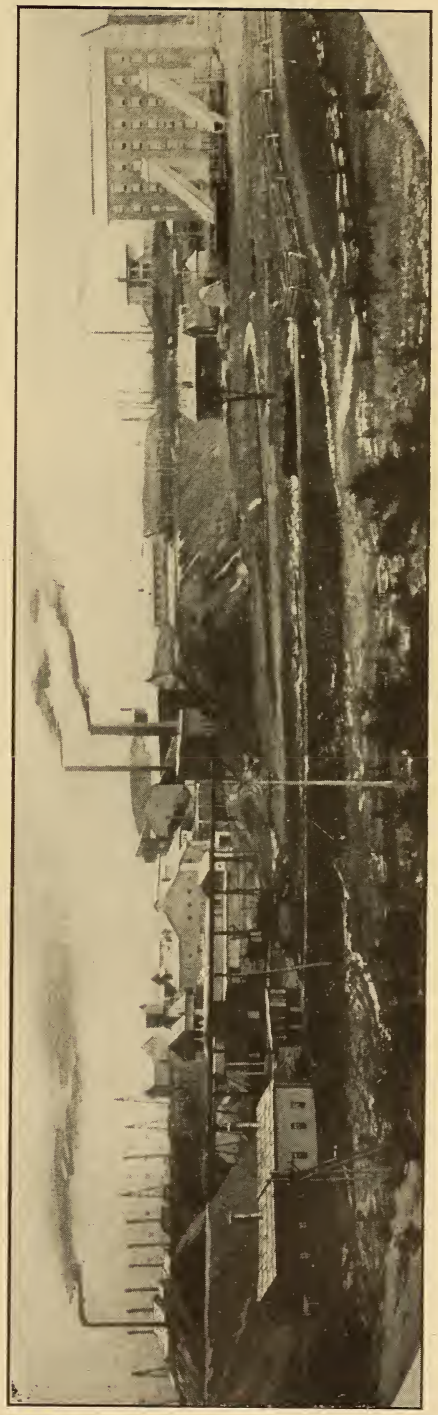
NATIVE CANADIAN ASBESTOS

Once put into exportable shape, Canada's asbestos is, for the most part, sent to the United States. The average amount thus annually exported to her neighbor during the decade ending June 30, 1904, was about 15,000 tons, having a value of about $450,000, or $30 per ton. Great Britain took, during the same period, an average annual tonnage of about 2,700, at about $50 per ton. Germany imported similarly 1,500 tons per year, at about $40 per ton. There is reason to think that the imports of Great Britain and Germany have been falling off. This, if really the case, is probably because of the increasing importance of the Russian source of supply. However, Russia is not yet a very formidable competitor. If we added to her production the totals produced by the United States, Cape Colony and Cyprus, we shall have an aggregate of, say, about 20 per cent. that of Canada.

Canadian asbestos is properly known as *chrysotile*. Apart from the hydrous character, chrysotile is chemically very similar to the Italian amianthus. The two have many things in common in respect to their industrial qualities. In appearance and form, however, they are quite distince. Chrysotile is fibrous serpentine in "small veins, laces or stringers." It may be yellow, greenish-yellow, bright green or some darker green. There is also a blue Canadian asbestos. The fibre is quite short as compared with amianthus. Temperatures up to 3,000 degrees F. are readily withstood. In fact, a temperature of 5,000 degrees seems to have no damaging effect upon some varieties. The fibre is fine, flexible and elastic, and possesses some tensile strength. The surface is quite smooth. Here is a point of differentiation from vegetable fibre. The smoothness of the fibre, combined with the shortness, made it very difficult to spin asbestos into thread. However, asbestos thread can now be spun so fine that a hundred yards or more will weigh but an ounce. Nearly all Canadian fibre is less than an inch in length. As the fibre lies in the vein, it is perpendicular to the non-fibrous surface between which the vein lies. As has already been said, Canadian asbestos

is hydrous. The amount of water may be 14 per cent. or more. In general, it is thought that the greater the percentage of water, the softer the asbestos. It has been noted that when water is driven off by means of heat, the asbestos becomes harsher. Ferrous oxide and alumina are present in nearly equal mounts, and form about 5 per cent. of the total weight. The remaining 81 per cent. of a typical specimen of chrysotile is partly evenly divided between silica and magnesia.

As asbestos occurs at or near the surface, the methods of mining are quite simple. The rock bearing the fibre is dug out or dislodged from an open pit. The amount of refuse forms such a considerable percentage of the total amount of rock that it would be a serious mistake to dump it near the mouth of the pit, where it would probably soon interfere with advantageous working. The serpentine rock bearing the chrysotile may have a covering of from 15 to 20 feet of soil, as is the case in the principal mining district in Canada. It is important, considering the climate of Eastern Quebec, where this district is situated, to remove the soil during the warm weather, and so avoid the expensive operations which would be necessary in winter. Here the steam shovel is the great piece of apparatus. The serpentine in the region of Thatford and Black Lake often contains large layers of slate, schist and diorite. In fact, the serpentine which bears the asbestos may be interrupted here and there by vertical strata of hard and barren rock. In mining, there will be the temptation to leave such pillars in. Sooner or later, however, they will have to be removed, and the wisest course in the long run, probably, is to deal with them at once. In this matter the smaller and larger concerns naturally pursue different policies—the smaller ones being governed, perhaps, by the question of immediate expense. The result is that the mines of the smaller companies are



THE LARGEST ASBESTOS MINES IN THE WORLD, DANVILLE, QUEBEC, CANADA

EL CHEER, A VERY RICH ASBESTOS LOCALITY IN MONGOLIA

quite irregular in outline; the larger mines, on the other hand, have a reasonably regular form. The rock is blasted out with dynamite, the cartridges being put into holes 8 or 10 feet deep, and the dislodgment is accomplished often for 3 cents per ton. Undoubtedly, the best general means of removing the results of blasting is the cableway. This may have a length of 400 feet. One method is to use two ropes for control—one to effect the translation of the carriage, the other to accomplish the hoisting of the load. However, by arranging the main cable at an angle of 30 degrees upwards from the pit, only one control rope need be employed. The carriage without load is permitted to run to the desired position over the mouth of the pit. Here a stop-dog arrests it. By paying out the hoisting rope, the load can be secured. Reversing it, the load will be lifted, the inclination of 30 degrees being sufficient to resist a translational movement until the load is up, when translation will begin. None of the pits was deeper than 165 feet a few years back, but this depth has now probably been exceeded. The horizontal movement of the load was perhaps no more than 300 feet. It is said that continuous operation of a single 40-horse-power cableway was competent to the handling of a ton in two minutes or a little over. However, the cableway is so useful for miscellaneous work that it does not often operate without interruption for long periods. Tram cars are used for hauling to a distance. When power is employed it is customary to use a queer little locomotive that is quite short. This little engine can round very sharp curves, and is accordingly found to be very useful. A locomotive of this type can be secured for about $2,000. The track is 42-inch gauge. A day's work for such a locomotive will amount to a mileage of perhaps 50 or 60.

The loads on the tram cars will naturally vary betwen barren and fruitful rock. The asbestos-bearing rock is divided into two classes. Some cars will be loaded with rock containing the longer fibre—from 5/16 inch up to, say, 1 inch. Others will contain the less valuable rock bearing the shorter fibre and scrap-

ings. In case some of this material contains too much moisture, it will be sent to the dryer. In any case, it finds its way sooner or later to the mill, where it is dealt with mechanically. The rock containing the long fibres goes to the cobbing sheds, where hand treatment is given it. The cobbing is performed by men and girls, and is quite a primitive procedure. The operator breaks up the rock on a suitable surface—as of steel—by means of a hammer. In crushed in the crusher, which was, of course, a more expeditious method than the hand hammer. By screening, some of the fibre could now be recovered. The remainder, however, revolving on a table, would undergo hand picking to remove the non-fibrous rock. After drying, the asbestos-bearing rock would be put through rolls and then suffer further crushing. Some of these procedures would be repeated perhaps, and mechanical agitation and blowing

ROAD TO THE URAL ASBESTOS MINES, SHOWING DIFFICULTY OF ACCESS

this way the fibres are loosened from the non-fibrous rock. To complete the separation, sieves are found of service. The fibres are now roughly graded. If they are not shorter than ¾ inch they belong to grade No. 1. If the length lies between 5/16 and ¾ inch, then the grade is No. 2. Shorter lengths go to the mill.

It was about twelve years after the discovery of commercial deposits that mechanical methods were inaugurated. The equipment consisted of such machines as a rock crusher, picking tables, Cornish rolls, revolving screens, shakers, blowers, etc. The rock would be mechanically brought in to assist. The grand object was to get the fibre free from the non-fibrous rock without unduly damaging it. The mechanical processes which have just been outlined were simply adaptations of procedures invented for other applications, and not especially designed to meet the particular difficulties of asbestos separation. Consequently, we are not to be surprised to learn that success was only moderate. What was needed was a procedure that would go to the root of the difficulties and solve them as equal difficulties had been solved by the cotton gin. In the case of asbestos, it is apparently

WATER FRONT AT PERM, HEAD OF NAVIGATION ON RIVER KAMA, ASIATIC URALS

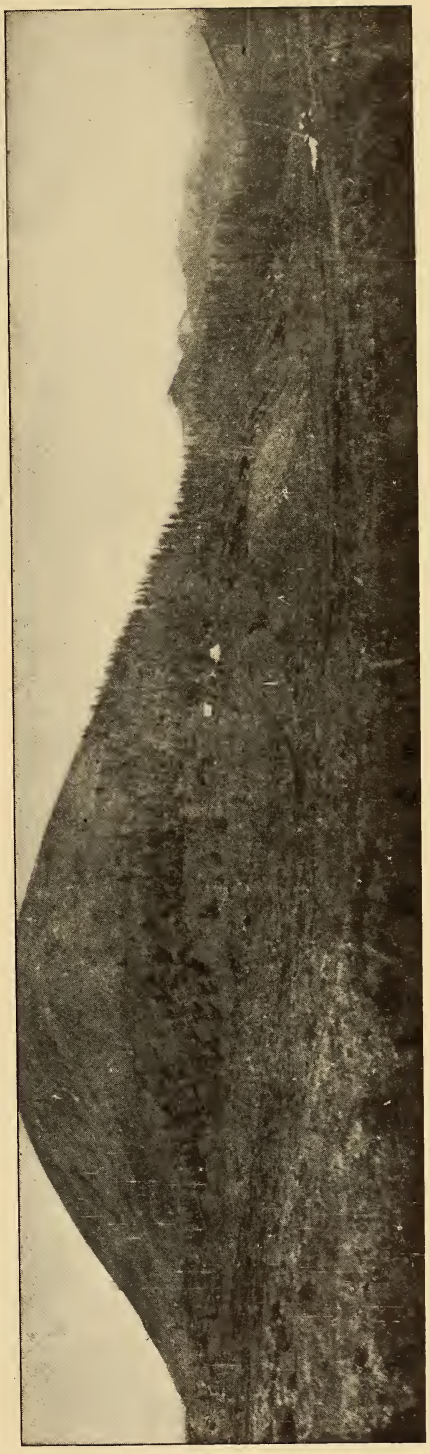
necessary to crush to fineness the non-fibrous rock. The fibre, moreover, must be reasonably preserved. It is doubtful whether this problem has received an adequate solution as yet. However, a machine known as the cyclone deals with the matter very well. Its name is appropriate, as will be seen. From two diametrically opposite directions the ends of rotatable shafts enter a good-sized chamber. Upon these shafts, and within the chamber, devices similar to propellers are arranged. These are rotated in opposite directions by suitable driving mechanism outside. A terrific commotion of the air ensues. Rock is fed into the region of the "cyclone" in lumps about 1 or 1½ inches in diameter. These are violently thrown about, striking each other and the walls of the chamber. There are openings at the bottom of the chamber. An exhaust is provided above. In this way is brought about an upgoing current. The smaller pieces are thus drawn off and discharged. Vibrating screens may be used to effect a further treatment. The "propeller" blades have a very short life of a fortnight, or even less. A percentage of fibre is spoiled, which must be reckoned as part of the cost of operation. Otherwise the separation is accomplished with very good success. There is another machine, although probably not equal to the "cyclone." This is the *beater*. Sets of radial arms carrying "teeth or knives" are mounted on a long, horizontal shaft. A cylindrical shell of boiler plate envelops the sets of arms. This is closed at each end, and suitable provision made to journal the shaft. This is driven at about 600 revolutions per minute. Material fed in amidships from above is discharged at the ends; or, fed in at the ends, it is discharged amidships. It is whirled about and cut up, and thus separation takes place.

Tailings are in some cases dealt with in emery mills. In the horizontal variety, two disks are arranged one above the other with their faces horizontal. The lower disk is rotated, and may be adjusted vertically. Such a mill 3½ feet in diameter and operated at 300 or 350 revolutions per minute will grind about 2 tons per hour. A vertical ar-

rangement of the disks is also in use. It seems that such a mill of 2½ feet diameter, or of about one-half the grinding area, has about the same capacity when driven at double the speed. The fibreized material, because of its comparative bulk, may be withdrawn by suction arrangements. Thus, a fan of suitable size operated at from 1,800 to 2,200 revolutions per minute is competent for such work.

A consideration of the early processes through which the large rock must go, and of the probable occurrence in the mine, will often be found in the mass of material. Such fragments would undoubtedly damage grinding, separating and other machines through which it might have to pass. The electro-magnet has been found serviceable in their elimination. The Manhattan Asbestos Company employs a strong electro-magnet of the horseshoe form. This is placed with its terminals just above a point where the material is passing along. The Broughton Asbestos Company uses a group of half a dozen magnets. These operate over a shaking screen.

Canada has been producing asbestos continuously now for about thirty years. In 1880 the output was 380 short tons, which had a value of $24,700. For eleven years (1880-1890) the value never ceased to increase year by year, in spite of the fact that there was slight recession in weight of output in 1888. In 1889 the averge value per ton was nearly $70. The following year it rose to nearly $128. The next year, output, total value and average value per ton fell. In fact, the ton value dropped off about $20. For the entire period from 1880 to 1904, there has been a steady increase of the output. However, it fell off a little —as already noted in 1888; 1901, it rose to a maximum point. In that year 32,892 tons were produced; the total value almost equaled the maximum value, year 1890, amounting to $1,248,645. From 1890 to 1904 the



EL CHEER, NORTHERN MONGOLIA. A LOCALITY RICH IN ASBESTOS, BUT DIFFICULT OF ACCESS

MONGOLIAN BOORIATS, THE NATIVES IN THE REGION OF THE ASBESTOS MINES

total value has fluctuated very considerably. In 1904 a tonnage of 35,068 was produced, which had a value of $1,154,566. In the four succeeding years (1905-1909) the production went up sharply, ranging from 50,669 to 66,548 tons, although the final year was not the maximum year.

In order to have a true idea of the real production of asbestos one must take into account a material known as asbestic. This is a composite of serpentine and true asbes-

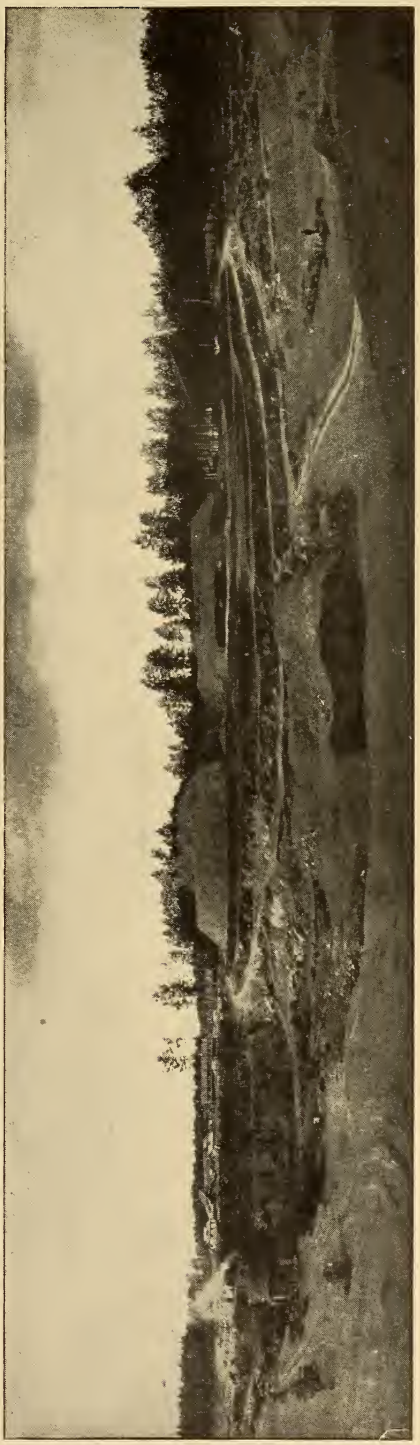
WOMEN WASHING THE ASBESTOS CONGLOMERATE OF THE URALS. A LITTLE GOLD IS ALSO FOUND

tos. The material resulting from the mixture is valuable because of its high resistance to fire. It is much used as a fireproofing material. The production of asbestic began in 1896, when 1,358 tons were produced. The following year 17,240 tons were manufactured. But in the following years, up to and including 1904, this tonnage was not equaled or very closely approached. The average value has fallen off from about $5 per ton at the beginning to $1 in 1904.

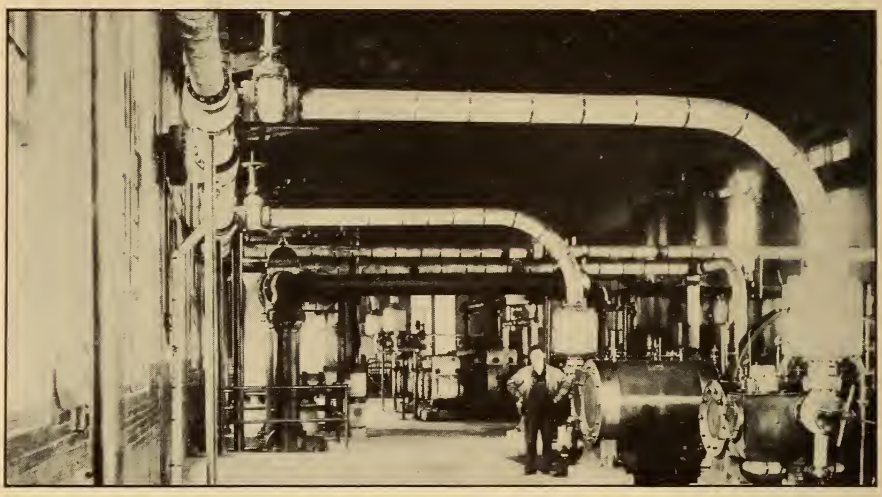
Canada exports nearly the whole of the asbestos produced. Thus, in 1895 she produced 8,756 tons and exported 8,593 tons. In fact, in 1898 and 1902 the exportations exceeded the production apparently, showing that stock on hand was being drawn upon. The United States is the country to which the bulk of the output goes. In 1895 the United States took nearly 70 per cent. of the output; in 1904 the percentage was about the same. Great Britain is Canada's next best customer, although in 1900 Germany imported more asbestos from Canada than did the mother country. In 1895 Great Britain absorbed about 26 per cent. of Canada's output; in 1904 she took less than 13 per cent.

The total capacity per day of the Canadian mines and mills is about 4,500 to 5,000 tons. The oldest concern is the Johnson Asbestos Company, operating in the Thatford and Black Lake districts. Altogether there are perhaps fifteen companies of considerable size working the Canadian fields.

While the United States has been perhaps the principal consumer of asbestos in the world, it has been only recently that its operations in mining have been worthy of much notice. Even to-day its output is only about 5 per cent. of Canada's. Still this is not quite a negligible thing. Asbestos in the United States is found in six principal locations: neighborhood of Lowell, Vt.; Casper, Wyo.; Grand Canyon, Ariz.; Sall



ASBESTOS MINES OF BARON GIRAR DE SOUKANTON, ASIATIC URALS



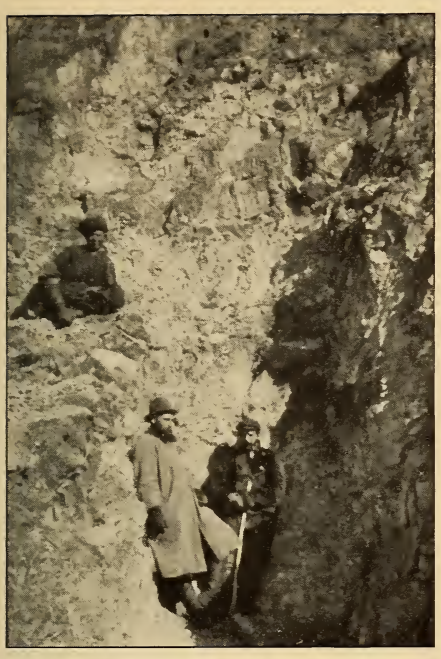
APPLICATION OF ASBESTOS COVERING TO STEAM PIPES

Mountain, Ga.; Kamiah, Ida., and Bedford, Va. The asbestos of Vermont, Wyoming and Arizona is chrysotile. The fibre found in Arizona in the depths of the Grand Canyon is silky and long. The exploitation of this deposit is, however, hindered by the inaccessibility of the location.

There seems to be a great deal of asbestos in Mongolia, but here, too, the question of accessibility will probably hinder development for some time to come. There are large deposits in the Ural Mountains of Russia. It is said that at Ekaterinberg an asbestos fine fibre, silky and tensionally strong, is found. It is accordingly valuable because of the excellent spinning qualities. The labourers are paid from 33 to 38 cents per day, together with free lodging.

Asbestos fibre has been examined under the microscope, particularly by Mr. A. Kingsburg. When a magnification of 90 diameters was employed no limit to the subdivisions of the fibre could be discovered. A power of 900 diameters was brought into service. Even with this strong magnification there were fibres so fine that they could scarcely be discerned. It is estimated that they must have had a diameter of about 1/200,000 inch.

One of the earliest commercial applications of asbestos in the United States is said to have been as a binder in certain kinds of cement employed formerly to cover the hot-blast pipes connected with furnaces. Subsequently asbestos cement was applied to steam pipes to prevent radiation of heat. Afterwards, so we are told, asbestos paper sheathing was used as a protection to combustible coverings. In the manufacture of molded sectional forms asbestos was found useful as a binder in connection with magnesia. To-day the chief application of asbestos lies in the manufacture of paper used in building and also as pipe coverings. Asbestos shingles is a line of manufacture which absorbs a very large amount of the asbestos produced. This material is now being applied to the protection from the effects of fire of metal used in building construction. Certain fabrics used in making automobile tires also add to the demand for asbestos. The modern automobile brake also employs asbestos in its friction facing. Further, asbestos seems to be displacing rubber as a steam packing. Asbestos is not only a poor



AN ASBESTOS VEIN IN SIBERIA

heat conductor, but it is also an excellent electric insulator. It is being applied by the users and manufacturers of electric apparatus in the form of insulating tapes, etc.

A novel application of asbestos is in connection with ropes used by firemen and the like. Such rope is made entirely of asbestos and also of asbestos with a steel wire core. A rope with a steel wire core and ¾ inch in diameter was tested by the German government. Such a rope was found capable of carrying nearly 2,000 pounds. One strand only of the seventy or more was broken. As to stretching, such a rope of ¾ inch diameter was found to be elongated only three-tenths of 1 per cent. by a strain of 220 pounds. Increasing the weight to 880 pounds resulted in an elongation of less than 1 per cent. It is said that asbestos rope made without the steel core is sufficiently strong for the ordinary applications made by the fireman. Safe loads are said to be 200 pounds for the ½-inch size, 300 pounds for the ¾-inch size, and 500 pounds for the 1-inch size. These sizes weigh about 10, 20 and 40 pounds, respectively, per 100 feet, and have many useful applications.

BASIC ECONOMICS

By H. F. Stimpson

THE origin of all businesses is to be found in the daily needs of the individuals of which the community is composed. This proposition is also true as respects the functions of a republican government, and is its chief distinctive characteristic.

Any given operation can be performed to the best advantage by one who has acquired especial dexterity therein. Such dexterity is invariably communicated by others, either directly by immediate illustration or indirectly by training in the processes of observation, analysis and synthesis.

The interests of the community are best conserved, therefore, by such a division of labour, mental or otherwise, that all of the tasks necessary for the satisfaction of its daily needs are performed by specialists rather than amateurs.

Under such an arrangement each individual renders his especial kind of service to many others, and also benefits by the services of what is usually a far greater number of individuals. Hence the obvious importance of the necessity of a common denominator, in whose terms the relative values of the services which are rendered directly and also the values of the commodities which are produced by other services may be so expressed as to facilitate comparison and exchange, the necessity for the development of methods for making extremely accurate measurements of the values which are to be so expressed being of equal importance.

As a matter of fact, while the desirability of the first of these necessities, at least, has long been realized, the majority of the efforts towards its acquirement have taken the form of attempts to accomplish by human finite and arbitrary legislation that which can only be accomplished by the intelligent application of the principles embraced in superhuman, infinite laws which have been the foundation of the greatest, so called, human achievements. The majority of mankind even yet consider a principle more in the light of a rule operating within narrow limits only than as of universal applicability, such being the essential characteristic of a principle.

Our failure to determine the denominator and methods of measurement above described is our chief basic error of omission; our basic error of commission grows from this, and is our faulty conception of the true function of money. We glibly say that it is to "measure" value, as if that were all that were necessary, forgetting that a thing must exist before it can be measured. The correct description of the function of money is to give tangible expression to values which have been previously determined and measured by other means. The weak spot in the commercial methods of man is his failure to determine, measure and express values with a degree of intelligence and scientific accuracy commensurate with many other of his operations.

In determining a denominator which shall be really common to all varieties of service and to all the varieties of commodities produced by service, it is axiomatic—

(a) That such a characteristic must be one actually and naturally

resident within the service or commodity, and not one artificially applied thereto or injected therein;

(b) That all service is simply an application of some form of energy;

(c) That the immediate sources of energy in Nature now known to man are:

1. Food of human beings, which is transformed into both directive and motive energy;
2. Food of animals;
3. Fuel;
4. Falling water;
5. Moving air; these last four being capable of transformation into motive power only.

(d) That the remote source of all these immediate sources of energy is the sun.

Such being the case, it is clear that all of the varieties of energy perceptible to our senses being derived from a common source must be simply different manifestations of the same thing, just as an idea may be expressed in different languages, or as the current supplied to a street car manifests itself simultaneously and differently as heat, light and motive power.

The differences between the varieties of energy, generally speaking, are those of volume and intensity, this being particularly perceptible in the case of electrical currents.

As all commodities are the results of the application of some form of energy to materials which are themselves inert, and which have, integrally, no common property whereby their values may be compared, it would also seem to be axiomatic—

(a) That in energy is to be found the correct common denominator for the comparison of the values of all services and commodities;

(b) That the determination, mathematically, of the ratios which now actually exist between the different types of energy, as to their power to produce one another, is the first step which must be taken toward the accurate determination of values;

(c) As, under the present condition of wide separation between the points of production and consumption no individual can possibly become personally acquainted with the quantities and qualities of energy rendered in the service or absorbed by the commodities which he requires, such quantities and qualities in the common interest must be certified to by a properly qualified branch of the Federal Government for the same reasons and with the same practicability that the certification to the quantity and quality of metal in a coin is now made by an existing branch thereof.

We shall then be able, for purposes of exchange, accurately to compare the values of the services of the highest executive of an enterprise or the ablest professional man with those of the lowliest worker, and, also, the values of the commodities produced by them in whole or in part.

Each individual will then see that his legitimate welfare will be far more enhanced by preventing an overcharge on the part of the many of whom he buys than by collecting an overcharge from the few to whom he sells, this being, in most cases, a mathematical impossibility incapable of execution under ordinary circumstances.

Our present inequivalent exchanges of values, due chiefly to the ignorance of the buyer, is the root of most of our economic as well as of our moral ills. Hence, as we satisfy our daily needs, in by far the large majority of instances, by purchasing from others, the accurate determination of values, as above indicated, is of increasing and overwhelming importance to each and every individual.

Every individual, therefore, should immediately endeavor to imitate and earnestly continue a movement to bring about such legislation as will establish a branch of his government for the rendition of this most essentially important service.

THE FIRST TRANSATLANTIC DIESEL LINER

By M. B. Cea

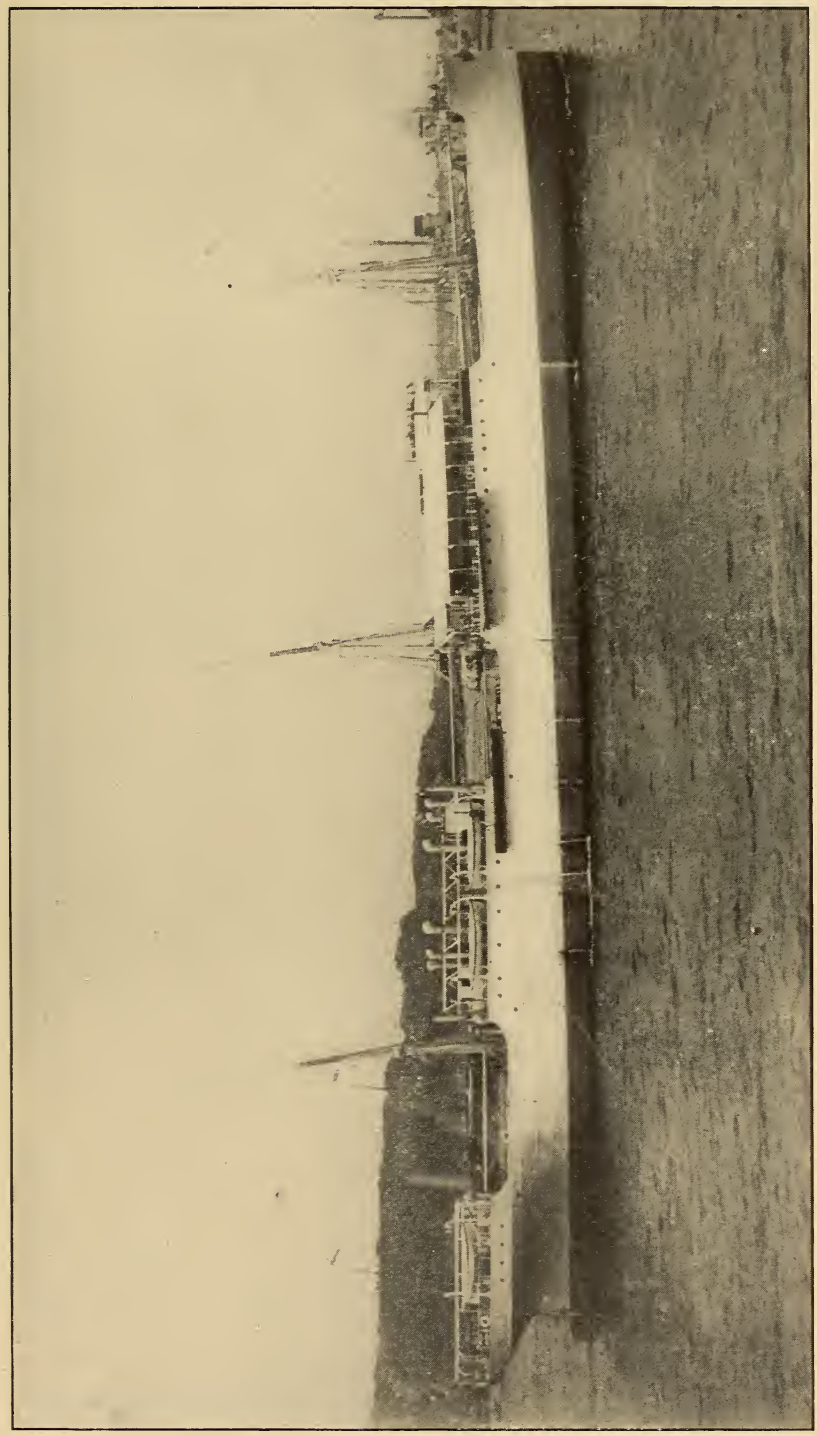
ALTHOUGH the motor boat driven by gasoline engines has been known and appreciated for a number of years, and some of these little boats have made voyages of considerable length, such as from New York to Bermuda, it is only very recently that any attempts have been made to equip merchant vessels with internal-combustion motors for the main propelling engines. This is due to the fact that gasoline is unsuitable for such service, and because high thermal efficiency, ordinary oil fuel and simplicity of control must all be combined to make a marine motor capable of superseding the steam engine. The first two of these requirements have been met by the Diesel engine ever since its original introduction for land service, and since the question of controlling and reversing has been fully solved in the modern marine Diesel engine, the practicability of the oil engine on shipboard, using the fuel directly in the cylinder instead of the indirect method of burning it under steam boilers, has been fully assured.

It is now just about one hundred years since steam power was successfully applied to marine propulsion, and we now have in active service a vessel which represents a much larger and more fully developed application of the oil engine than Fulton's *Clermont* or Bell's *Comet* did of the steam engine a hundred years ago; and the consequences of this later development may be more rapid and far-reaching than those of the former achievement.

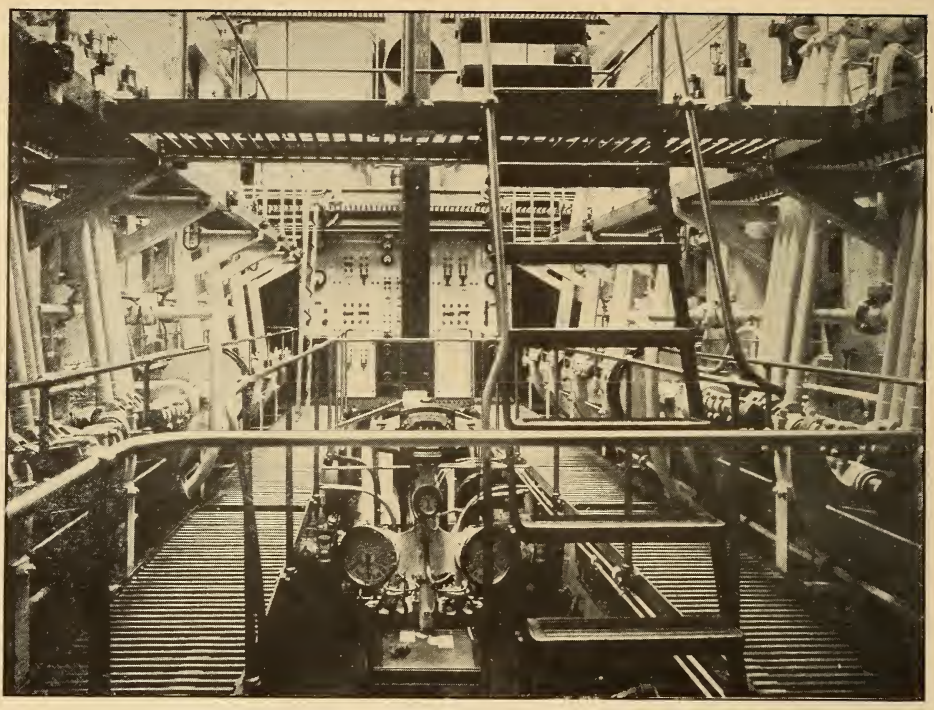
It has been truly said that the arrival of the Diesel-engined vessel *Christian X,* of the Hamburg-American Line, in American waters marks a new date in marine construction. This vessel, the first of her type to cross the Atlantic, has completely fulfilled all expectations in a most exhaustive test, and has attracted critical attention, both from the engineering profession and from the traveling public. The general opinion seems to indicate that this pioneer ship will be followed by a fleet of vessels propelled by internal-combustion motors, using ordinary fuel oil, or even the liquid tarry residue derived from the coking of coal.

It may be desirable to review some of the differences between such a vessel and the ordinary steamship of similar general character. Everyone who has examined a steam-propelled vessel must realize what a serious thing it is to carry a power house full of steam machinery within the limited space available on shipboard. The fuel itself, in the form of coal, is bulky, dirty and difficult to handle, not only in the initial operation of coaling, but in the far more troublesome work of stoking into the intensely hot furnaces by what is one of the most exhausting and objectionable kinds of work—a work which has not yet been found practicable to replace by any effective mechanical appliance. Not only the firing of the boilers, but the cleaning of the fires and the quenching and removal of the ash and clinkers, must be done by hand, in contracted quarters, under most difficult conditions, and there is little doubt that the work of the stokers on board a steamship represents the most objectionable duty to be performed anywhere.

The boilers themselves take up



THE CHRISTIAN X, THE FIRST OIL POWER STEAMER TO CROSS THE ATLANTIC



THE ENGINE ROOM OF THE CHRISTIAN X, SHOWING DIESEL ENGINES

much room, and are subject to many troubles. They must be kept clean and tight; the steam pressure must be maintained as uniform and steady as possible, in all weathers and under all circumstances; they must be supplied with clean water, through pipe connections which themselves demand continual attention, and the steam which they produce must be delivered to engines through mains which involve still further care.

In the engine room, apart from the propelling machinery itself, there must be a mass of auxiliary machinery, consuming much steam, involving further piping, and including the handling and movement of large volumes of water.

When the introduction of oil fuel was advocated it was at first proposed to burn it under the steam boilers, and even this moderate advance was hailed as a great step forward, since it enabled most of the difficulties of coaling and stoking to be replaced by the simple mechanical processes of receiving and feeding a liquid fuel. The brutal work of the stoker, at least, might thus be avoided. There remained yet, however, all the inconveniences accompanying the generation and use of steam, and it was realized that the advantage gained by burning oil in place of coal was only the beginning of the transformation. With the perfection of the Diesel engine, however, the problem was in condition to be completely solved, and in the *Christian X* the whole advantage of the change may be clearly seen.

In the first place, the entire boiler equipment, with all its associated piping for steam and for water, is omitted, and the space formerly required is made available for revenue-producing cargo. In the second place, the coal bunkers are no longer required, and since the oil fuel is carried in the double bottom of the ship, the bunker space is also added to the increased cargo room. In the case of the *Christian X*, it is esti-

mated that about 15 per cent. of valuable space is thus gained.

The removal of any necessity for coal handling and stoking dispenses with coal passers and firemen and effects a marked economy in operation, since a crew of only ten men in the engine room is required, as against one of forty-five men in a steamship of the same size. The oil fuel is delivered directly into the tanks from the shore supply through a temporary pipe connection, no trouble in passing and trimming being required and no dust or dirt created on or about the ship.

As is well known, the Diesel engine has a remarkably high thermal efficiency, and this enables not only a very efficient generation of power to be conducted, but also gives a very large radius of operation for a single loading of fuel. Thus, an ordinary steamship is obliged to coal frequently, and her voyages must be governed to a considerable extent by the opportunities of taking on suitable fuel. The oil-propelled vessel, on the contrary, owing both to the large fuel capacity and the low fuel consumption, is far more independent of fuel stations than any steamship could be. This is clearly shown by the fact that the *Christian X* is capable of carrying in her double bottoms a supply of 1,000 tons of crude fuel oil, while the consumption is only 10 tons a day, the vessel traveling at a speed of 12 knots. This means that 12 nautical miles an hour, or 288 miles a day, may be made with an expenditure of 10 tons of fuel oil, or the 1,000 tons taken on at one loading would suffice to propel the ship more than 28,000 miles, a distance greater than the circumference of the earth, in a voyage of 100 days' duration.

The *Christian X*, built by Burmeister & Wain, of Copenhagen, and named for the King of Denmark, is 370 feet long and 53 feet beam, with hurricane deck 30 feet above the waterline. The displacement, when loaded, is about 9,800 tons, and the carrying capacity 7,400 tons—an excellent indication of the large proportion available for useful purposes. The motive power is supplied by two Diesel four-cylinder engines, each having eight cylinders, developing a total of 2,500 horse-power. The engines are very smooth in running, no vibration being perceptible, even at full speed.

The control of the machinery in this vessel is remarkable, and is effected by the use of compressed air, both for starting and reversing, the reversal from full speed ahead to full speed astern being effected in eight seconds. The compressed air is maintained at a pressure of 300 pounds per square inch in a reservoir, both for starting and reversing purposes, and also to serve as the first stage in the regular air supply to the engines, the air taken from this tank being compressed to the second stage, of 900 pounds per square inch for fuel injection. The oil fuel is taken from the main tanks into working tanks, each containing about sufficient for one day's run, thus keeping the immediate supply distinct from the main tanks. Since there are no boiler furnaces, there is no need for chimneys or funnels, and after the gases discharged from the engines have been cooled in an exhaust chamber they are discharged into the air through a hollow mast at a height of 40 feet above the deck.

The auxiliary apparatus of the motor liner is in duplicate, in order to insure against delays by reason of accident. The dynamos and the air compressors, each in duplicate, are driven by two Diesel engines of 250 horse-power. The dynamos supply electric current for operating the pumping plant, the cooling machines, the steering machinery and the cargo winches, while the compressors supply the air for the main engines.

There are two sets of bilge pumps, warm water pumps and cold water pumps, which may also be connected with the fire mains. The refrigerating machine, driven by electricity, is

of the carbonic acid type. The entire mechanical plant, except the donkey boiler and the thrust bearings, takes up only about 43 feet of the length of the ship, while this boiler and the bearings are contained in a separate space 8 feet long and 22 feet wide.

The *Christian X* has four cargo holds beneath the main deck and one hold on the main deck, the total capacity of these holds being 370,000 cubic feet. Seven watertight compartments are provided, to insure safety in case of collision.

While this vessel has been constructed primarily for carrying freight, she is provided with passenger accommodations of the best class for a limited number of persons. The cabins are unusually spacious and convenient, while the ladies' room and the smoking-room are furnished in accordance with modern standards of luxury at sea. The vessel is fitted with wireless telegraph apparatus, and she represents the latest technical development of marine equipment.

Probably the feature about the *Christian X* which attracts the most attention is the absence of anything indicating the character of the motive power. As shown in the illustration, there are no funnels, and no smoke is produced, while the entire effect of the boat is pleasing and satisfactory.

THE RAILWAYS OF SOUTH AMERICA

II.—NORMAL GAUGE RAILWAYS OF URUGUAY AND ARGENTINA

By R. Renewal

Montevideo Harbour.—Any data concerning the Central of Uruguay Railway would be incomplete without a few words about Montevideo Harbour, whose influence is so strongly felt by the whole system.

The construction of these harbour works was decided in 1899 (decree of Nov. 7, 1899). Tenders were called for by the Government, and those offered by a French syndicate were accepted on Jan. 4, 1901, for a total sum of 60,000,000 francs (roughly £2,400,000).

The works were destined to provide Montevideo with a harbour having at low water a depth of 25 feet, sufficient for all steamers now plying between Europe and La Plata, and for the works to be so constructed that simple dredging could deepen the water any time to 32 feet should the size of the vessels (as seems likely) shortly render such extra depth useful.

The town of Montevideo is built upon a picturesque promontory, running into the sea in an east by west direction. The harbour consists of a commercial port, on the northern side of this promontory, and of an outer harbour, forming an extension of it.

The outer harbour involved the construction of two breakwaters, one called the east breakwater, 940 meters long, the other called the west breakwater, 1,000 meters long. These breakwaters rest on an artificial foundation made by substituting a large amount of stone and sand to the mud dredged off the bottom. On this rest two lines of concrete blocks, weighing 30 tons each. This involved a large amount of dredging (altogether some 9,000,000 cubic meters) to a depth of 60 feet below sea water, at the breakwaters' heads.

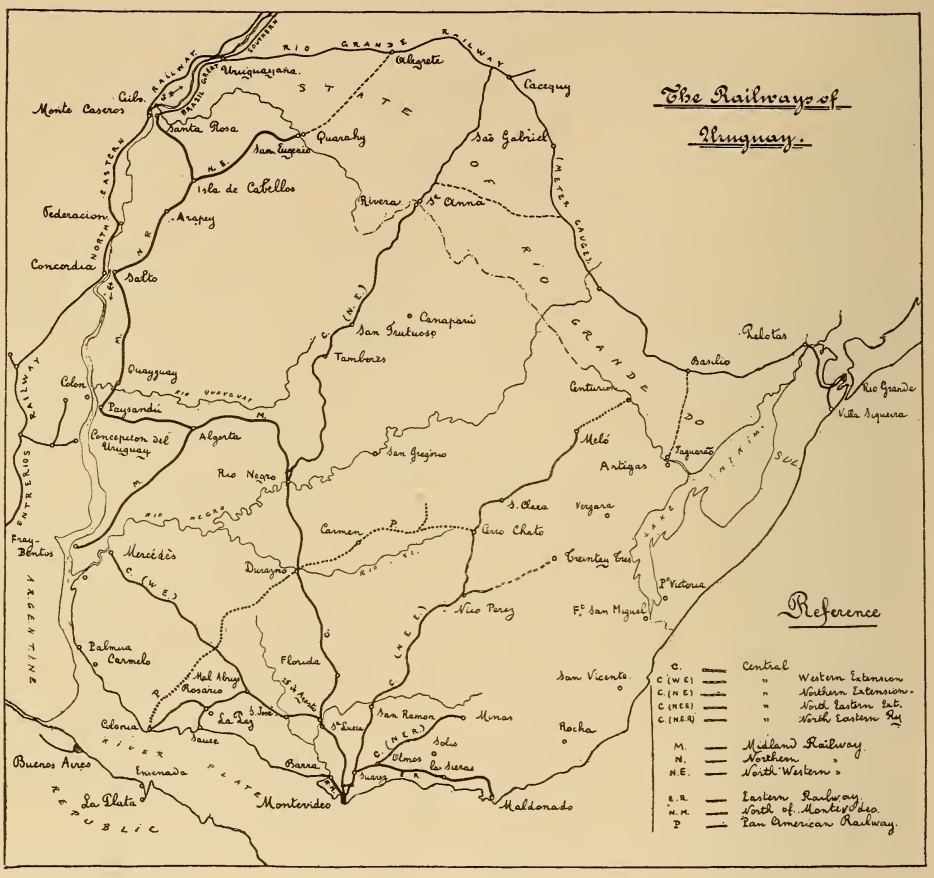
An entrance channel, 4 kilometers long, the outer harbour, and commercial port are all dredged to a uniform 25-foot depth.

This commercial port is protected from the sea on the north side by an interior sea wall. On the land side there is a sea wall round the port, some 2 kilometers in length, about the same as the interior sea wall, with an extension of quay walls, including a wooden quay, 500 meters long. The commercial port is divided into two docks by two moles, and a good deal of filling in (some 4,000,000 cubic meters) was done so as to form a terreplein, with an area of 60 hectares (150 acres).

The quay walls of the moles were built by two floating workshops.

One hundred and seventy-six pillars were built at a distance of 8 meters from each other, the intervening space being closed by curtains of ferro-concrete sheet piles, covered with lintels of the same material. The upper portion of the wall is made of blue and pink granite, brought from the company's stone quarries in La Toja, 4 kilometers distant.

Each pillar was half built in 55-ton caissons, which one of the two floating workshops helped to float. It was then lowered into its place at a depth of 10m50 (34 feet) onto a horizontal space prepared for it by the divers. The second workshop then completed it. Each pillar forms a stone and concrete block of 550 cubic meters weighing 1,250 tons. Each was tested with an extra load


The Railways of Uruguay.
Reference
C. Central
C (W E) " Western Extension
C (N E) " Northern Extension
C (NE E) " North Eastern Ext.
C (NE R) " North Eastern Ry
M. Midland Railway
N. Northern "
N.E. North Western "
E.R. Eastern Railway
N.M. North of Montevideo
P. Pan American Railway
Monte Caseros
Concordia
Salto
Paysandú
Fray-Bentos
Mercédès
Colonia
Buenos Aires
La Plata
Montevideo
Maldonado
Rocha
Minas
Florida
Durazno
Carmen
Rio Negro
Tacuarembó
Melo
Rivera
Artigas
Rio Grande
Pelotas
Bagé
Santa Rosa
Quaraby
Isla de Cabellos
Federacion
Arroyo
Colon
Quaygua
Concepcion del Uruguay
Algorta
Tambores
San Gregorio
Vergara
Cerro Chato
Nico Perez
Trinidad
Sarandi del Yi
Sarandi
Soles
Olmos
Las Aceras
Pan
Rosario
Mal Abrigo
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Barra
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Canelones
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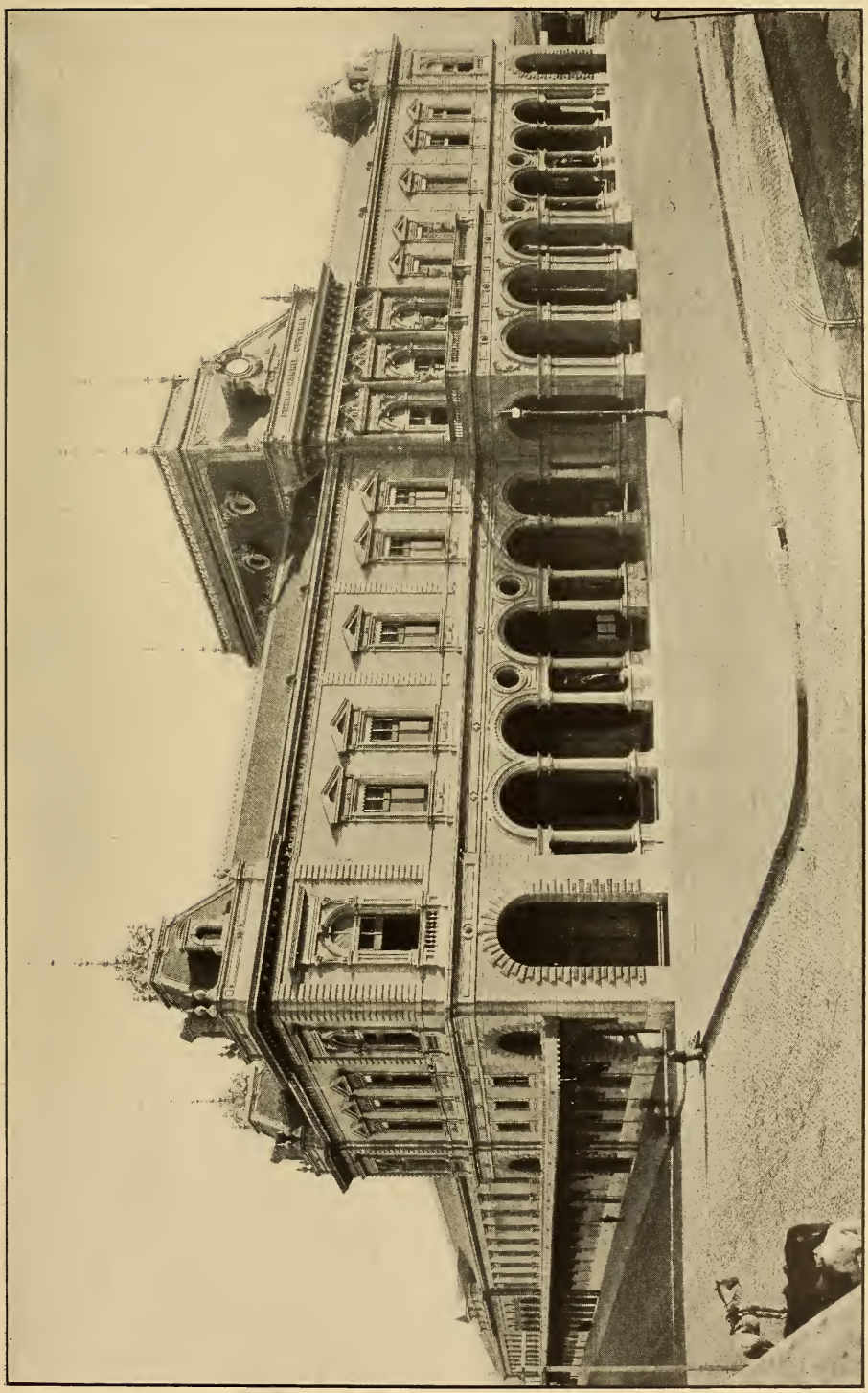
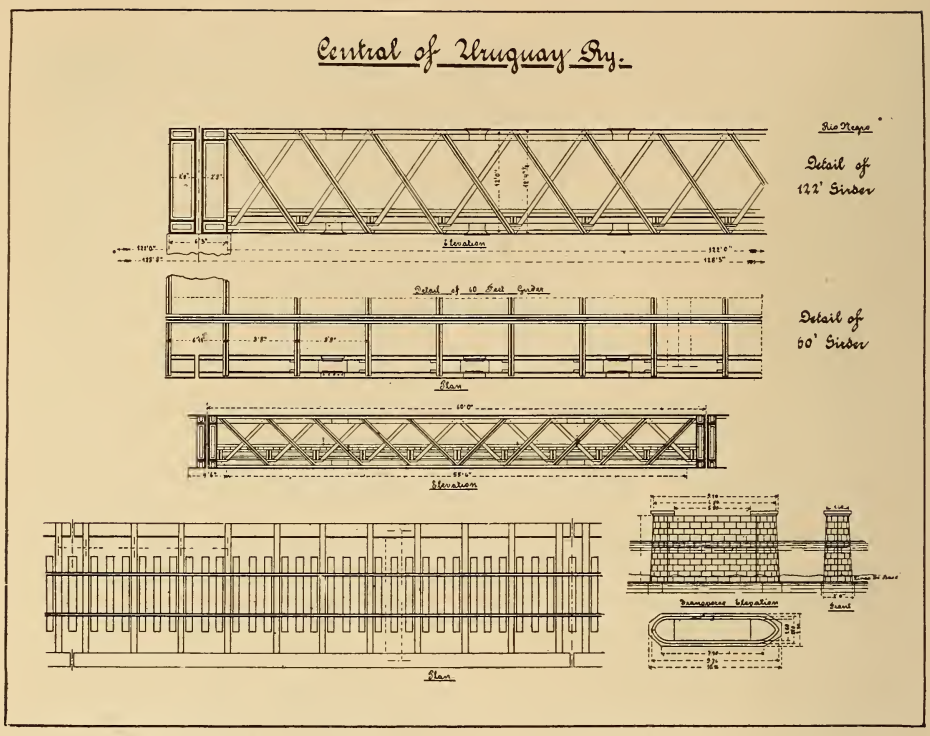
Cerrito
Palmar
Carmelo
Conchillas
Sauce
Juanicó



STATION OF THE CENTRAL RAILWAY OF URUGUAY AT MONTEVIDEO



DETAILS OF RIO NEGRO BRIDGE, CENTRAL RAILWAY OF URUGUAY

terminal. The new entrance channel would be dredged as far as the interior of the bay to a depth of 12 meters, and the whole of the port to 10, including the foot of new wharves to be constructed on the reclaimed land.

The embankment to be built at the mouth of the Miguelete would contribute 180 hectares of such land, and this would be filled in as usual by the dredgers. There would also be a new wharf parallel to the existing one, and a new basin near the station of the Central of Uruguay Railway, with four wharves where dredging to a depth of 5 meters will supply accommodation for the river craft.

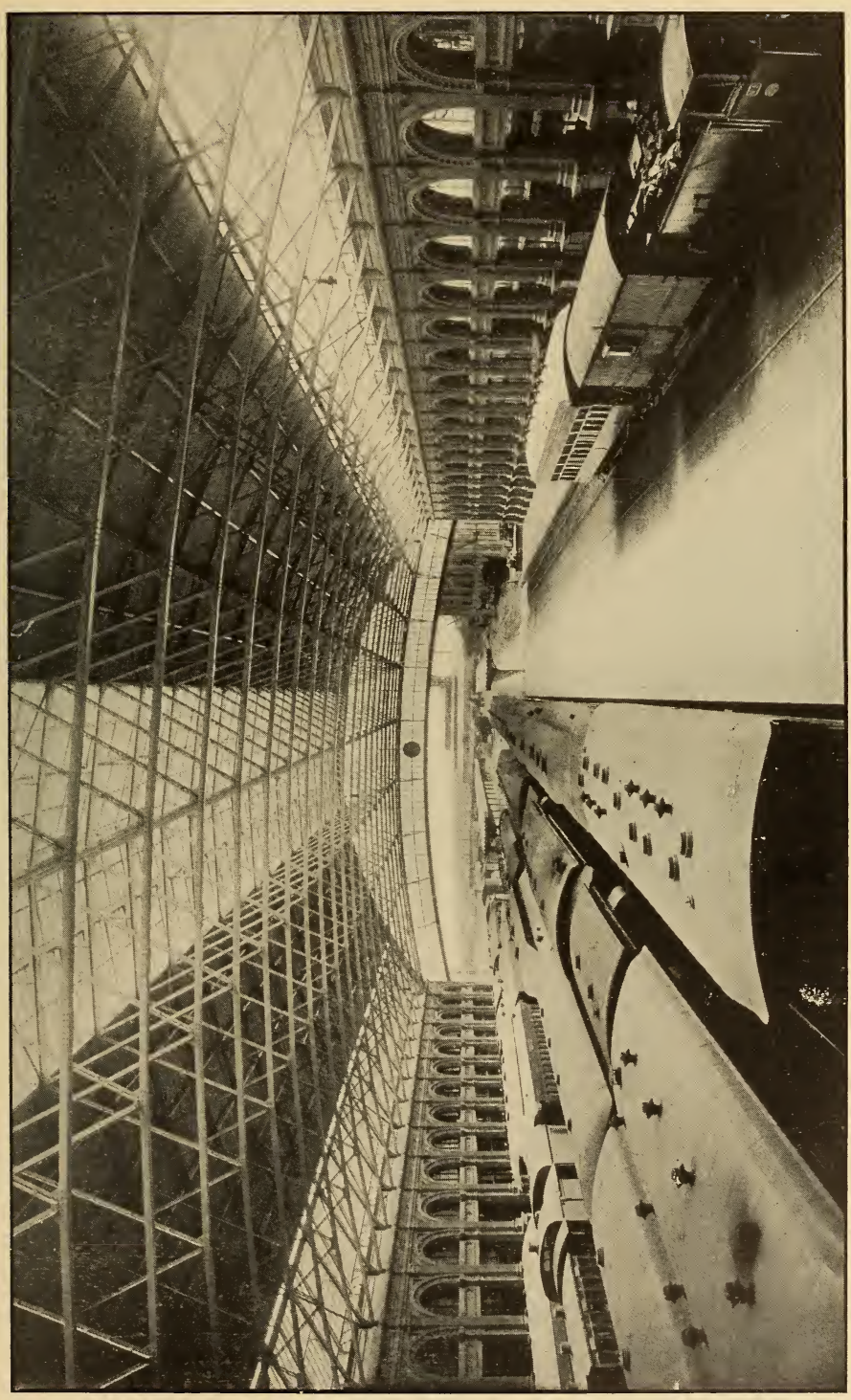
The 12-meter channel will terminate on the south side of the new embankment, where a deep-water wharf will be constructed.

The works are to comprise a new dry dock in the ante-port, a basin for the river steamers, and a port for the fishing craft along the Sarandi breakwater in the ante-port. The ante-port will be dredged to a depth of 10 meters, which will be protected by an extension of the western breakwater.

B. THE MIDLAND GROUP OF RAILWAYS

The eastern portion of the Republic is not served by the Central Railway of Uruguay. Several other companies own short lines in this district, and economical conditions have prompted them to practice a policy of close co-operation. To begin with, these lines are more sections of one single road than separate undertakings, and when a financial hazard so divides the roads it almost always happens that they either amalgamate or come to working agreements. Then, taken together, these lines give a competitive route from the coast to the interior and into Brazil.

We will therefore examine them together, but it must be understood they constitute three distinct com-



INTERIOR VIEW OF TRAIN SHED OF THE MONTEVIDEO RAILWAY STATION

panies, though some of the officials of the roads are the same.

The Midland of Uruguay's line starts from Rio Negro (at the 273d kilometer of the Central Railway), which is situated in the middle of the Republic, and runs west to Paysandu, on the banks of Rio Uruguay (129th mile), and follows the bank northwards to Salto (199th mile).

All these lines are laid to the same gauge as the Central of Uruguay's, viz., 4 feet 8½ inches.

Midland Railway.—When the Midland Railway's line was decided (on August 27, 1884) it was as a branch of the fanlike system of the Central Railway, starting from Paso de los Torros, beyond the Rio Negro Bridge, and running straight to Sal-

A COLONIST'S RANCH, SHOWING METHOD OF DRYING MEAT

This town is the upper limit of navigability of the river.

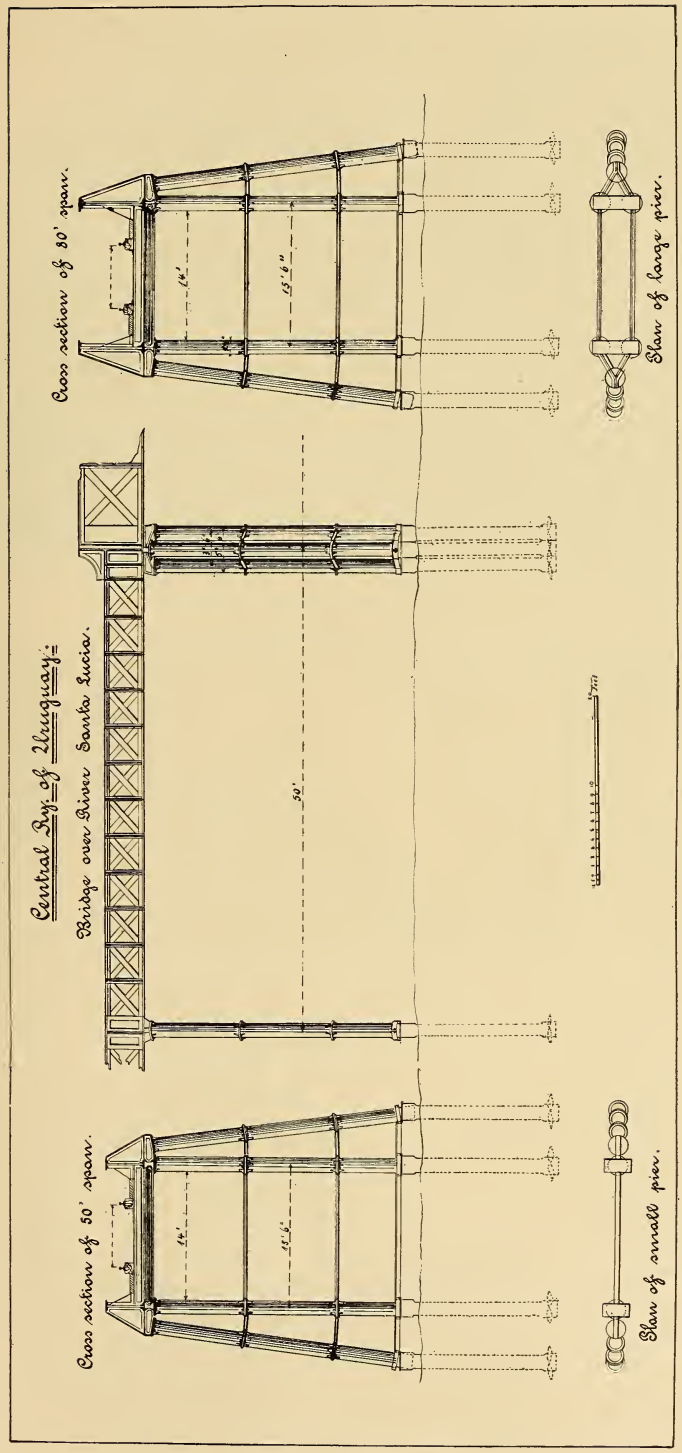
The North Western of Uruguay Railway runs along the river bank from Salto to the frontier of Brazil at Santa Rosa (108th mile), on the southern bank of the Rio Cuareim, an affluent of the Rio Uruguay. The Brazil Great Southern's line starts from the opposite bank and opens up connections with the Brazilian railways.

From Isla de Cabellos, a small station at the 70th mile of the North Western of Uruguay Railway, a branch runs to the frontier of Brazil. This is 71 miles long, and belongs to the Uruguay Northern Railway.

to, with a sub-branch to Paysandu, thus draining the Provinces of Salto and Paysandu at the profit of Montevideo.

However, as the North Western's line was building from Salto northward, and as river traffic could reach that town, the Central Railway thought it inexpedient to build this line, and the decree of Nov. 12, 1884, conceded it to Messrs. Conrad Hughes and Thomas Watson. These gentlemen transferred their concessions to Mr. Henry Gale (July 12, 1887), who handed it on to the Midland Railway (July 26, 1887).

As the line ceased to be a branch of the Central Railway, the location



SANTA LUCIA BRIDGE—CENTRAL RAILWAY OF URUGUAY

MONTE CASEROS STATION. N. E. ARGENTIA RAILWAY

was changed. The road was to start from Paso de los Torros (now called Rio Negro) as heretofore, and, running through Algorta, a rich sheep-raising land, run straight to Paysandu, carrying cattle and merchandise both ways; either towards the Central Railway and Montevideo (eastward) or westward to the river, where it was to be embarked.

This section was opened to traffic on August 15, 1889. The section from Paysandu to Salto, along the river bank, was opened on Nov. 1, 1890. This second portion was built as a line linking the first section to the Northern roads beyond Salto. As such it did not prove a success. Most of the freight would, of course, descend by water from Salto, instead of rail to Paysandu and river beyond.

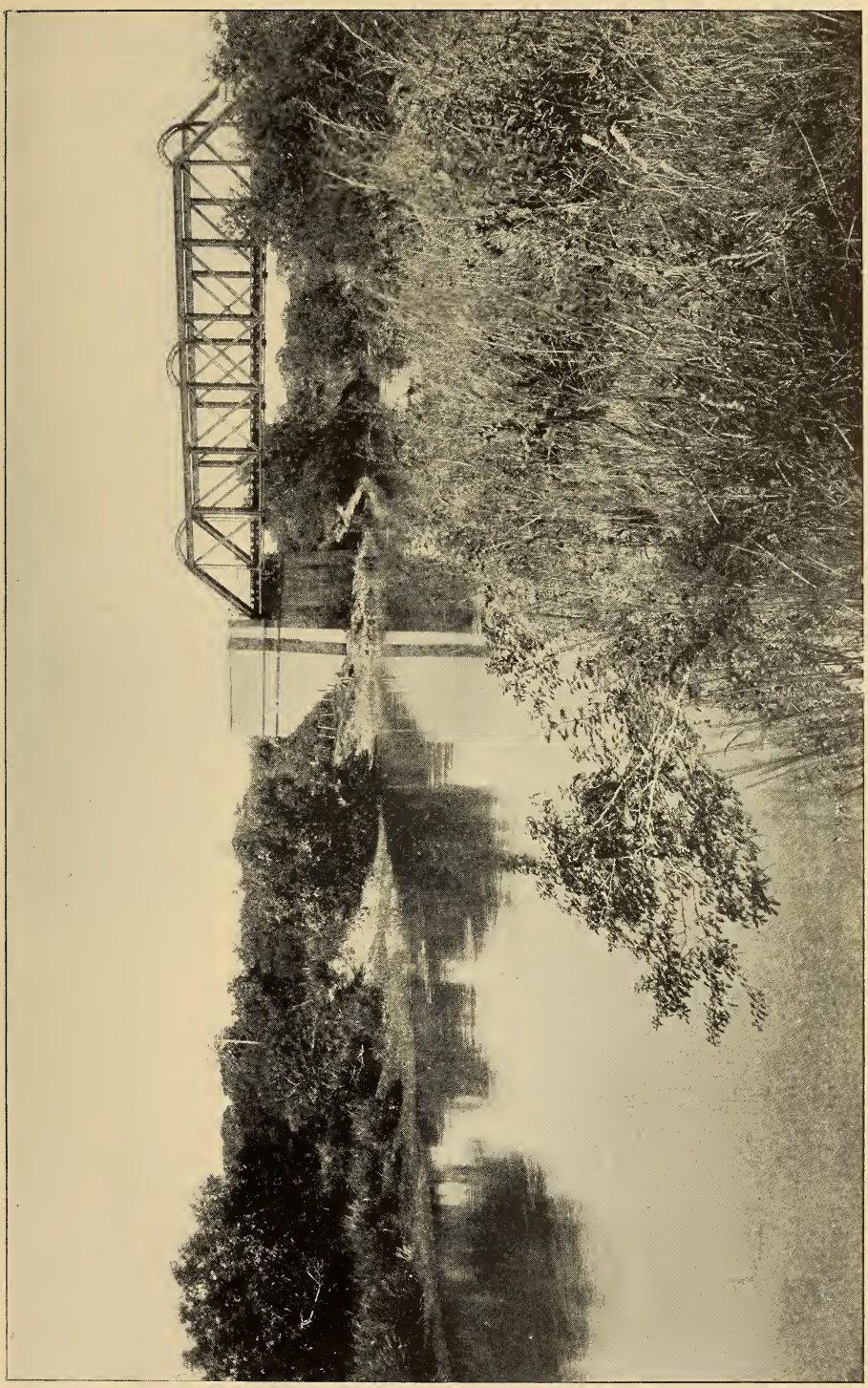
The line had the usual 3½ per cent. State guarantee on $24,327 gold per kilometer.

The bridging included the bridge over the Arroyo Salsipuedes (nine 37-meter spans, altogether 333 meters), over the Rio Quegay (two 50-meter spans and five 20-meter, altogether 200 meters), and the big bridge over the Rio Dayman (three 20-meter spans and thirty-nine 10-meters, altogether 450 meters).

Realizing the limited possibilities of the road, such as it was, the company decided to turn to profit its capabilities as an exportation line, ceasing to be a tributary of Montevideo.

The Rio Uruguay is always navigable for ocean-going steamers up to Fray Bentos (well known in connection with Liebig's properties there), and its navigation is often impeded above, though small draft steamers can always get up to Salto.

The Midland therefore decided to build a line connecting its main line with Fray Bentos, which has been declared a port of entry, diverting all the traffic from the northern roads to that port instead of Montevideo. The company spared no expense in building a mole capable of receiving ocean-going steamers drawing up to 24 feet of water, a draft, in fact, that exceeds the average depth of water in the Rio Uruguay. Fray Bentos will therefore shortly rank as the second seaport of the Republic and may compete successfully for a



THE SAN LORENZO BRIDGE, ARGENTINA

portion at least of Montevideo's traffic.

The first portion of this Fray Bentos extension (55½ kilometers) was opened on August 3, 1910, and the entire line on July 1, 1911.

With the same object in view, the Midland Railway has started a cut-off between its main line and the Northern Extension of the Central Railway, from its station of Tres Arboles to the latter's Pedra Sola, some 35 kilometers distant. This will give Fray Bentos yet another

A COLONIST'S SETTLEMENT IN MISSIONES PROVINCE, ARGENTINA

radiating line to Algorta Rivera and the center of the State of Rio Grande do Sul, which it will bring within lesser distance of Fray Bentos than of Montevideo.

The *North Western of Uruguay Railway* owns some port works in the Rio Uruguay at Salto. Running inland first from the river banks, so as to establish a physical connection with the Midland, where traffic interchange takes place, it then turns off northwards.

The original concession, on Feb. 8, 1881, was given under the same clauses as those of the Central Railawy, including a guarantee of interest higher than was afterwards deemed advisable.

The first section, from Salto to Jacuy, 97½ kilometers (61 miles), had this guarantee. The company agreed to forfeit this upon payment of $771,539 gold as compensation, and $1,028,460 as cancellation of this guarantee. On the other hand, it agreed to extend the line immediately from Jacuy to the frontier of Brazil.

This it did, and opened this section on April 20, 1887. The total length is 187.8 kilometers (117 miles).

As this latter portion had a 7 per cent. guarantee of interest, the contract was revised on June 30, 1885, and it was decided that the net profits of both sections should be taken into account, so as to calculate the net profits per kilometer, and that this result should be applicable to the section having a Government guarantee.

The Rio Uruguay, being navigable until Salto, and no further, this line was built with the intention of providing a mixed water and rail way up to Uruguayana, in Brazil, whence

LOADING A CATTLE TRAIN ON THE NORTH EASTERN ARGENTINE RAILWAY

navigation can be resumed up stream. The Argentine line, on the opposite bank, has the same end in view, hence competition, not between the two railways only, but between the two countries as well.

The original concession advised the building of a bridge across the Rio Cuareim, on whose southern bank the line terminates, so as to connect it with the Brazil Great Southern's line, on the opposite bank. However, so far, nothing has been done, and it is only in July, 1911, that a British company called the Rio Cuareim International Bridge Company was floated with this end in view.

Slow development has been one of the characteristics of railway growth in the Republic, which is no doubt due to the frequency of political unsettleness and the ensuing instability in economical prospects.

The construction of this line, along a large river's banks, has implied a good deal of bridge building, and some uneven running, grades reaching 1 in 60, as on the other roads.

The bridge over the Rio Arapey, 1,155 feet long, is approached from the north side by a viaduct of eighteen 42½-foot spans. It has three wrought iron spans of 130 feet each, supported on wrought iron columns 60 feet high, on concrete foundations.

The Lake Arapey is crossed on a bridge consisting of five 42½-foot spans and one 32-foot span.

The only other large bridge is the one across the Rio Jacuy at the end of the first section, six 50-foot spans.

The *Uruguay Railway* runs from Isla de Cabellos to Sao Eugenio, on the southern bank of the Rio Cuareim. This is the Uruguayan portion of the town, the Brazilian portion, on the northern bank, being called "Quarahim." A new line is in construction between this point and Alegrete on the Rio Grande do Sul Railway system. The Isla de Cabellos and Alegrete line will thus become an alternate international route between the two Republics.

The original concession of the Uruguay Northern line was granted to Mr. Edward Morrice, a director of the North Western of Uruguay Railway, who transferred it to the London Joint Stock Association.

The line was opened to traffic in 1890-1891.

A great portion of its traffic accrues to it from the Brazilian side of the frontier, where several jerked meat factories have been established.

Two ropeways belonging to the railway span the river Quarahim between San Eugenio and the principal of these factories.

Such is the Midland group of railways at present, not very important so far owing to the sparsely populated nature of the country it lies in, but with every prospect of a good future before it, the extensions into Brazil on the one hand, and down to Fray Bentos on the other, altering

SAN DIEGO, A TYPICAL SOUTH AMERICAN RAILWAY STATION

the erstwhile local undertaking into a system with a definite political orientation.

C. INTERIOR RAILWAY OF URUGUAY

The general railways act that stated the lines radiating inland from Montevideo had left a gap of some 400 kilometers (250 miles) at the northern frontier.

The law of Sept. 6, 1889, decreed a railway from Colonia, a port opposite and 31½ miles distant from Buenos Ayres, which was to run to San Luiz, on the Brazilian frontier, and eventually to Bagé. This line would cross the Western extension at El Pedrito, the Central at Durazno, and touch the North Eastern at Cerro Chato.

The line has not been built so far, though it has been revived at frequent intervals, but it is under construction now, and a few words about it are necessary. Its estimated length is 581 kilometers (363 miles), besides a 78 kilometer branch (48 miles) to Cerro Chato.

It was conceded to Messrs. Castro, Petty & Co. on Nov. 30, 1888. There was a 6 per cent. Government guarantee on £5,000 per kilometer. But it was not proceeded with.

On the Brazilian side there has been the same hesitancy about a line from Bagé to Porto Alegre, which was to continue it.

In 1911 the Pan-American Trans-Continental Railway Co., of the United States, made a definite start on the construction of the "Interior Railway." The guarantee is given under the 1891 law, up to a maximum of 3½ per cent., and applies on the section from Trinidad north (248 miles). The company is to build

MONTE CASEROS STATION, ARGENTINE NORTH EASTERN RAILWAY

port works at Colonia and a colonization clause has been introduced similar to those in force in Brazil, by which the company shall establish 1,000 families of emigrants on 15 square leagues of its land.

D. LIGHT RAILWAYS

So for, in spite of the 1888 law on Economical Railways, which has been quoted, no progress has been made in that direction.

But as the construction of such roads is particularly desirable in the agricultural and in the mining districts, a new law has recently been passed whose principal clauses are as follows:

Government finds the funds up to $300,000, which will be supplemented by the railways' reimbursements of sums above 6 per cent. dividends, and by a special taxation of 1½ centesimo per ton-kilometer on the light railways traffic, and contributions of the neighbouring landowners.

The lines can be granted either by the Executive, the landowners, if numbering at least half the number of those situated in a zone 7½ kilometers wide on either side of the projected line, or by the Councils, if they are willing to guarantee a traffic of $90 per annum-kilometer until the line earns a dividend of 3 per cent.

The lines must not cost more than $18,000 per kilometer and obey to the August 27, 1884, railway law.

A curious clause is the following: The proprietors in the 15 kilometers wide zone, comprising the line, and already referred to, must contribute to its traffic at least 20 tons per hectare and per year, or pay 1½ centesimos per ton-kilometer and per annum. And so as to compute these tons, grains, which are light for their bulk, are to be counted at four times their weight, and wool thirty times its weight. It seems hard on landowners who had not wanted the line, not only to see it built, but to be obliged to support it as well! Their only resource lies in the provision that should they be unwilling to obey the above clause they can be expropriated after three years at valuation (based on the taxation) plus 20 per cent.

This responsibility of the landowners begins two years after the opening of the lines and ceases after fourteen.

The lines are State built, but are worked by lessees on 10-year contracts.

The first line Government is about

to build is a line from Florida on the Central's main line to Sarandi.

Out of 19,576 miles open to traffic on January 1, 1911, in the Argentine Republic, there were 12,937 miles (or 62 per cent.) of fibre gauge (5 feet 6 inches) roads, 6,095 (or 30 per cent.) of meter gauge lines, and but 1,548 (barely 8 per cent.) of so called normal gauge railways, laid to 4 feet 8½ inches.

And this is almost an accidental gauge, due to peculiar circumstances; yet the lines so laid are as important as any and, though in such a minority, deserve more than the usual cursory examination that is vouchsafed them.

The system consists of all the railways situated in the longitudinal zone between the Parana and Uruguay Rivers, running north by south, some two degrees apart, the southernmost lines belonging to the "Entrerios Railway Company" (of London) and the northernmost to the "Argentine North Eastern Railway," British also. Further north beyond the Rio Alto Parana the Paraguay Central Railway is now laid to this same gauge, whilst in the south the Central of Buenos Aires Railway opens up connection with the capital of the Argentine Republic.

These companies now work:

	Miles.
Central of Buenos Aires	167
Entrerios Railway	727
Argentine North Eastern Railway	661
Paraguay Central Railway	240

Taken together, the system opens up through connection between Ascencion, the capital of the Republic of Paraguay, and Buenos Aires, in competition with the river steamers (belonging mostly to the Mihanovitch Steamship Company) and with the Ascencion & San Francisco, meter gauge route.

CENTRAL OF BUENOS AIRES RAILWAY

The Central of Buenos Aires Railway consists of a main line from Buenos Aires to Salto, Rojas, and Villa Maria (the latter portion building), and a branch to the port of Zarate, on the Rio Parana.

It was not destined to be a railway at all, the original scheme being a tramway system, which has grown into the present undertaking.

The oldest section (from the Plaza de Mayo to the Plaza II de Setiembre, in Buenos Aires, which has since been sold to the Anglo-Argentine Railway) was a horse tramway line, called the "Tramway Rural." This was extended, not in the city only, but beyond the suburbs into the country, one of the lines, which was granted on October 2, 1884, running out to Salto, a distance of 107 miles. With a view to develop the national industry of the country, then depending almost entirely on horse breeding, the concession stipulated horses should be used exclusively; and this clause has been obeyed, the Buenos Aires & Salto line holding the record for long-distance horse tram railways. It is also the only one, probably, to have run sleeping cars over its metals. This car, built by the Brill Company in 1886, contained four upper and four lower berths of steam car character. An outrider used to gallop in front, so as to announce its arrival a short time before reaching the localities it ran through.

Owing to the rapid growth of the system, it has been severed into two sections, the city lines becoming the "Lacroze Tramways" and the Salto line, with the branch from the 37th mile to Zarate, conceded in 1903, becoming the "Tramway Rural à Vapor."

Both sections are interesting, the city portion because of its high-speed interurban services and the "Rural" section because it has also grown into the railway now known as the "Central Railway of Buenos Aires."

The Salto line was opened in sections between 1888 and 1896. Originally a Provincial concession, it became "national" almost as soon as the whole road had been opened (31-12-1897) under the act on "Secundary Railways." Another step forward (in 1904) turned the line into a regular "railway" and granted

THE RAILWAY STATION AT SANTO TOME

an extension from Salto to Rojas (29 miles, opened 15-3-1909). A further extension from Rojas to Villa Maria (law 5083 of 28-5-1907) is now building. This rural line would thus become one of the important radial railways that characterize so curiously the system of the Argentine Republic. Some cross-country roads unite them, forming, at the intersections, new railway centres, which, in turn, other radial lines such as this will unite. Villa Maria is such a point, there being a broad gauge line in the same direction as the "Central of Buenos Aires" line on further to Cordoba, one of the important towns of the Republic. Could the "Central of Buenos Aires Railway" get there despite it (and the example of the two roads, laid to two gauges, paralleling each other right out to Tucuman proves the possibility), this line would have a brilliant future before it and pass from the rank of a provincial line to that of one of the trunk routes of the country.

The short branch to Zarato, on the Rio Parana (28 miles long, bringing that town within 60 miles of Buenos Aires), has recently gained considerable importance, owing to the extension of the railways of the Entrerios and Corriontes Provinces, whose trains find their way into the capital over its metals. It has been completely reconstructed.

The new passenger stock is particularly noticeable. It consists of bogie vestibuled trains, all cars being 55 feet 8 inches long over bodies and 60 feet 6⅛ inches over platforms (extreme length over side buffers, 63 feet 7⅞ inches), 10 feet wide over sills and sheathing, and 13 feet 6 inches high from rail to top of roof. The truck centres are 43 feet apart. The interior of the coaches is undivided, or divided into smokers and non-smokers only, as usual on South American trains. They have centre corridors and transversal, reversible seats, seating two passengers on either side. This arrangement is practically standard.

Such is the "Central of Buenos Aires Railway" in its present stage. But another phase is announced: the substitution of electricity for steam—yet another step away from the original horse propulsion. This will probably take place on similar lines to the equipment of the "Lacroze Tramways," so a short description of them will be useful.

In 1905, on the death of Frederico

Lacroze, a contract for their electrification was entered into with J. G. White & Co., of London, the reconstructed lines becoming the "Buenos Aires Lacrozé Tramways."

The speed at which this work was carried out, even had there not been labour troubles and port congestion, was remarkable. Work was begun in March, 1906, the new 2,250 kilowatts power house was in running order before the end of the year, and the first 30 miles of electrified lines were opened on March 10, 1907.

The electrification includes, besides the city portion, the suburban section of the "Buenos Aires Central Railway" between the Chacarita terminal and Linch station, besides branches to Saavedra, Urquiza and San Martin.

The lines are equipped with overhead cables at a height of 20 feet, each car having two trolleys.

The suburban cars of the high-speed interurban service are equipped for a maximum speed of 50 miles per hour. They have two 50 horse-power motors on each bogie, built by the British Westinghouse Electric Company. These cars, which seat 44 passengers, are 43 feet long, 7 feet 4½ inches wide and 12 feet 3 inches high. They have compressed air brakes and whistles. Besides 10 of these cars, the company has 7 electric locomotives, 119 city cars and 100 trailers.

Buenos Aires City Extension.—

THE PORT OF SANTO TOME, ON THE URUGUAY RIVER

Like all railways having their terminals in the outer suburbs of large towns, and particularly when there is a harbour, the "Central of Buenos Aires Railway" early realized the advisability of being able to get its freight and passenger traffic to the river side.

This was easy for the passengers. When the original company was divided into the urban and suburban sections the urban cars were given the right to run some distance out of Buenos Aires on the suburban section's metals. There are special sidings at the station where the interchange of passenger traffic is easily made.

In the same way the "Central Railways" freight traffic can travel over the Lacroze tramway lines to the Once station of the Oeste Railway. But, besides the inconvenience of running through the streets, the freight has to be transshipped at that terminal, as Government's Port lines (which are neutral) are laid to two gauges only—broad and meter, whereas the railways we are now examining are of the medium gauge (4 feet 8½ inches).

In 1911 the Lacroze Tramways therefore applied to Congress for permission to construct a tube from the Chacarita terminal to the Paseo de Julio, which would greatly facilitate its traffic with the Port. This tube was granted on the 9th of March, 1912.

The bill provides for two tracks, the permission to lay down two more, should necessity arise, and allows both passenger and goods traffic. The tube will unite Chacarita, not with the Port only, but with the Once goods station as well.

This is the last phase in the remarkable growth of this line.

The "Ferrocarril de la Plata," laid to the same 4-foot 8½-inch gauge, is a small, independent concern, 14 miles long, between the town of La Plata, the capital of the Province of Buenos Aires, and the station of Abaété. It is really hardly more than a steam tramway.

ENTRERIOS RAILWAY

The development of the Entrerios Railway is very similar to the growth of the Manchester, Sheffield & Lincolnshire Railway. Both began as provincial east and west roads. Both have since run a southern extension towards the Capital, which both reached over the metals of a suburban railway company (the Metropolitan Railway in one case and the Central of Buenos Aires in the other), and both have since sought to tap a northern traffic—the Scotch traffic at home and the Paraguayan traffic in the Argentine.

The cross-country main line runs from Parana, opposite the important town of Santa Fé, from which it is separated but by the Rio Parana, to the town of Uruguay, on the Rio Uruguay, and nearly opposite the town of Paysandu, in the Oriental Republic. Both rivers are navigable

A 2-6-0 LOCOMOTIVE ON THE ARGENTINE NORTH EASTERN RAILWAY

RIACHUELO BRIDGE. ARGENTINE NORTH EASTERN RAILWAY

up to these ports for large steamers.

This line, called the Entrerios Central Railway, was conceded between these ports on the 11-6-1883, by the Province of Entrerios. This explains why the line was built to normal gauge and why it did not run towards Buenos Aires. It was destined to foster local development without drainage towards the Federal Capital. The national law (No. 1529) of the 9-10-1884, allowed the National Government to pay half the Province's liabilities.

It was soon recognized this railway could not be worked independently of the river traffic, and harbour works at Bajada Grande, near Parana, and at Concepcion del Uruguay were decided (by Provincial laws of the 10-8-1885, and 18-1-1886).

South of the line the town of Victoria is a port on one of the arms of the Rio Parana, and Porto Ruiz, situated on an affluent (the Rio Gualeguay), is the harbour of the town of Gualeguay, nearby. On the Rio Uruguay there is a good port, called Gualeguaychu, opposite Fray Bentos, in the Oriental Republic; the river usually allows steamers drawing over 20 feet of water up to these towns.

Branches to Victoria, Gualeguay and Gualeguaychu were, therefore, decided in 1884, and a branch northwards to Villaguay in 1887.

Work was taken in hand, but Government ownership having a number of drawbacks, a Provincial law (29-10-1890) authorized the sale of the road. The railway was handed over to the shareholders in 1891 (on the 24-8), thereby forfeiting the national guarantee of interest (law 2831 of 2-10-1891), but being exonerated of all national, as opposed to provincial, taxation (28-10-1891).

On the 29-1-1892, the line became the property of the Entrerios Railway Company. The mileage was then as follows:

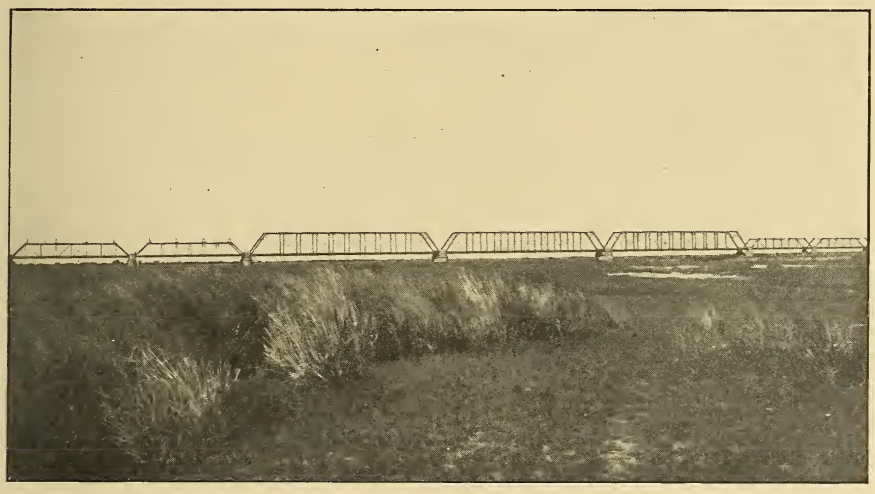
	Miles.
Baja Grande to Uruguay, conceded 11-6-1883, opened 1887	179
Nogoya to Victoria, conceded 7-1-1887, opened 26-6-1890	30
Talo to Gualeguay, conceded 7-1-1887, opened 30-1-1891	68
Basavilbaso to Gualeguaychu, conceded 7-1-1887,	62
	339

The new company's first increase of mileage is due to the purchase, in 1895, of the F. C. Entreriano. This short road, which is but 6 miles long, joins the Government port of Porto Ruiz to the town of Gualeguay, whence the Gualeguay & Tala, branch

of the Entrerios Railway, leads north. It was opened in 1866, and is one of the oldest lines of the Republic. The "Oeste," having but 63 miles, opened in 1857; the "Southern," 70, opened in 1866; the "Ensenada, 3, opened that same year, and the "north of Buenos Aires," 18, opened four years previously. Government was a shareholder from the outset, and bought up the road in 1887 (law 865), selling it to the Entrerios Railway in 1895 (law 3336).

1902. A short branch leads to the river side.

The southern extension is more interesting. The concession was granted in 1905, and work on the 63-mile line between Las Colas, just north of Gualeguay, the southernmost point reached, and Ibicuy, on the Parana River, some distance further upstream than Buenos Aires, was immediately taken in hand, the line being completed in March, 1908. The crossing of the river between Ibicuhy



AGUAPEY BRIDGE. ARGENTINE NORTH EASTERN RAILWAY

Though the new company built a short branch to Macia, the railway was still a cross-country road until the extension policy was started and an extension northwards to Concordia, an important town on the Rio Uruguay, was built. As in the case of the other harbours of this river, there is an important town, called Salto, on the opposite bank, reached by the Midland Railway of Uruguay. The river's navigability finishes here; and, curiously enough, neither of the two railways running from here downwards has built any further extensions northwards, the Argentine road, beyond, belonging to the obsolete East Argentine, and the Oriental road, to the North Western of Uruguay. Concordia was reached in

and Zarate is made by train transfer steamers in some few hours, the trains running through and over the Central of Buenos Aires Railway to the capital. A short connection, belonging to the Entrerios Company, leads from Zarate harbour to the station.

The opening of this section entirely altered the character of the line, turning it into a through connection from Buenos Aires to the Entrerios and Corrientes Provinces, the former stage of the railway having prepared the development sufficiently. The event was rightly considered to be one of national importance, the President of the Republic inaugurating the route officially on the 29-5-1908.

The train transfer steamers, of

which there are three in operation, were built on the Clyde.

The *Lucia Carbo,* twin-screw, has four boilers, and its speed is 14 knots.

The *Maria Perera,* twin-screw, and two boilers, has a speed of 11 knots.

The *Mercedes Lacroze,* simple screw and single boiler, has a speed of 8 knots.

Each of these steamers has a capacity of twelve passenger cars, or twenty 30-ton freight wagons, on three lines of rails. The cost per steamer-mile was 4*s.* 7*d.* in 1911.

The port of Ibicuhy has been considerably improved, ocean-going steamers drawing up to 25 feet being able to use it. It is equipped with numerous facilities for discharging cargo rapidly and for shipping grain and other products, which include steam band conveyors handling over 100 tons per hour, and Temperley transporters for dealing with coal.

The Government of the Province of Entrerios gave 740 acres of land, having a frontage of 1.86 miles, free, and a subvention to cover interest during construction of $1,000,000 in provincial currency bonds carrying 5 per cent. interest and 1 per cent. amortisation. At the same time, the company obtained an extension of the term of exemption from taxation, the concession of new lines, and other privileges.

The opening of such a route and the new direction of the railway's policies have rendered other lines necessary.

The most important is a cut-off between Enrique Carbo and Britos, 32 miles long, which was opened on the 1-12-1909, and which shortened the route northward by some 30 miles.

A branch was built from Caseros to Elisa and opened in 1907, and has since been extended 39 miles to San Salvador, giving an alternate route to the north.

Another branch to Hasenkamp was opened in 1907.

For some time past Government has been very keen on building a line from Diamante, a port in the southwest corner of this region running diagonally across it to Curuzu-Cuatia, on the North Eastern Railway. After much hesitation, the line called the "Eastern Railway" seems likely to run from Diamante to Crespo and Hasenkamp, making use between these two towns of the existing branch, on to Villa Federal and Curuzu-Cuatia. Originally an independent project, it was changed into two sections—the one granted to the Entrerios Railway, the other to the North Eastern. This company having no wish to build the line, the whole of it was turned over to the Entrerios Railway, who so far made no progress with it. Government has started building it, with, presumably, the intention of handing it over to the railway companies upon completion. Its length would be 215 miles (law 6341 of 15-9-1909).

The lines built by the Entrerois Railway Company are the following:

Sola to Macia, conceded 17-11-1898, opened 23-10-1899	13
Kilometer 59 to Hasenkamp, conceded 20-7-1905, opened 1-9-1907	48
Caseros to Villa Elisa, conceded 20-7-1905, opened 1-6-1907	23
Las Colas to Ibicuhy, conceded 20-7-1905, opened 1906-1908	63
Zarate connection, conceded 11-10-1905, opened 17-2-1908	1
Basavilbaso to Villaguay, conceded 11-10-1905, opened 17-2-1908	38
Neild to Concordia conceded 10-3-1901, opened 1901-1902	72
Enrique Carbo to Britos, opened 1-12-1909	32
	290

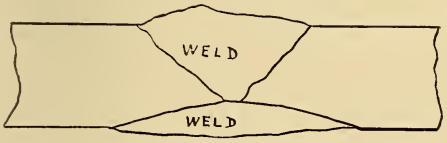
(To be continued.)

OXY-ACETYLENE WELDING FOR ORDINARY OPERATION

By James Steelman

IN welding operations, as conducted in the past, the workman was seriously limited by two things: the large mass of fire with which he had to deal and the moderate temperatures, comparatively speaking, which were at his disposal.

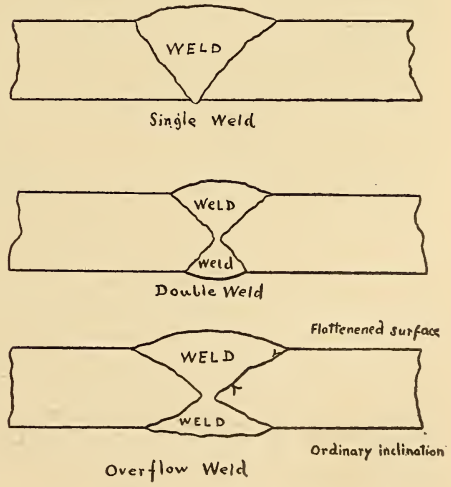
The oxy-acetylene welder, provided with a torch which furnishes a working flame at whose tip is a temperature of about 6,000 degrees Fahr., has a magnificent tool with which to operate. The workman must remember, however, that, though he has a tremendous temperature, he does not have a tremendous amount of heat. Still, he has a very considerable amount; and as to it he must be on his guard as to the way he manages.



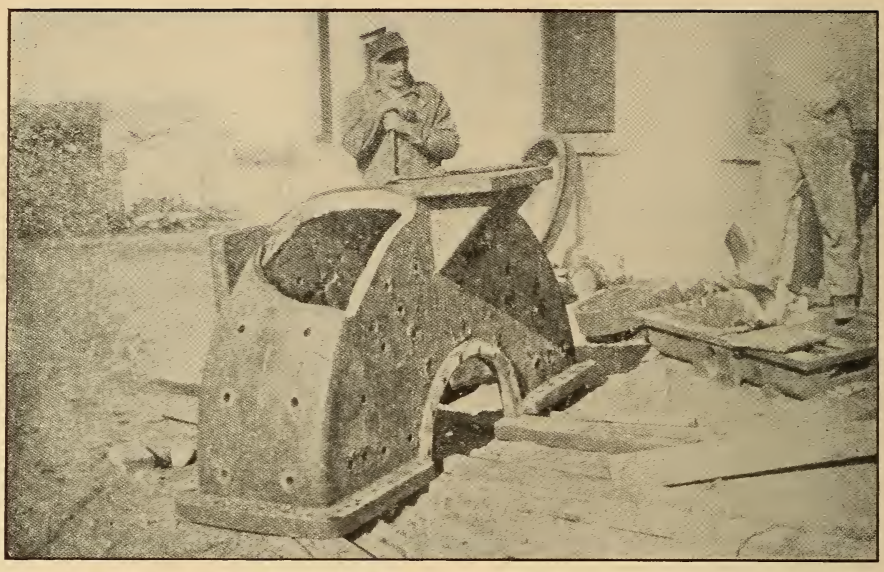
A TYPICAL CAST-IRON WELD

Because of the high concentration, he may easily overheat the metal at one point and underheat it at another. If the work is thin, he may easily melt through it in spots. With some metals, especially steel, too high a temperature would probably injure the quality of the metal involved. Because the amount of heat is not excessive, he may, especially if the work be heavy, lose much heat by conduction and radiation, and in consequence find difficulty in getting the metal to the temperature desired. The student of the subject will understand from the foregoing that the oxy-acetylene torch is not an instrument permitting of careless handling. On the other hand, the necessary skill and judgment required are quite reasonable.

Oxy-acetylene welding ordinarily differs from the welding with which the blacksmith is familiar. The blacksmith does not bring the metal to the melting point; he brings about union, in part, by the blows of his hammer: the particles are forced together. In ordinary oxy-acetylene welding, neither the hammer nor its equivalent is necessarily employed. It is necessary, then, that the metal at the surface where union is to take place shall be molten. The blacksmith often adds no new material. In a large percentage of cases of oxy-acetylene welding additional material is employed. That is to say the surfaces of the work are not directly joined. They are, as it were, soldered together by means of fresh metal. Great liberty is permitted in choosing this new material. It may be identical with the work or nearly so, or

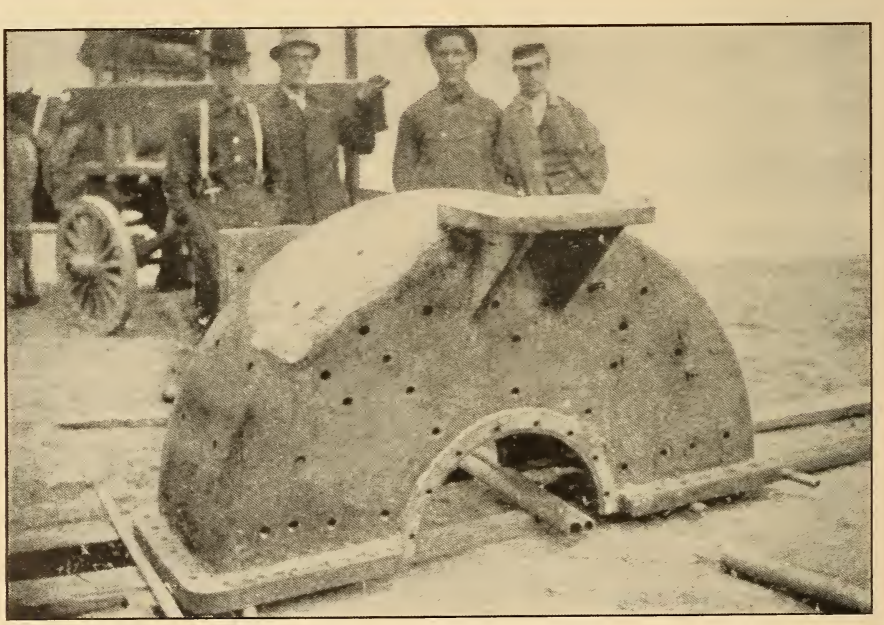


EXAMPLES OF VARIOUS WELDS



BROKEN CASING OF DREDGE PUMP, 2½ INCHES THICK

it may differ. This new material is melted in between those surfaces of the work that are to be united. The molten surfaces of the work and this fresh metal in the molten state unite because both are fluid, or nearly so. It will be gathered from this that it is highly important that the faces of the work shall be sufficiently heated. Further, it is very necessary that the whole of the faces be brought to the high temperature. If the faces have failed to reach the melting point in spots, we will have a defective weld. It is necessary, too, that there be no unmelted spots at the moment when



REPAIRED CASING OF DREDGE PUMP. LENGTH OF WELD SEAM, 11 FEET; TIME SAVED, THREE WEEKS

WELDING A TEE CONNECTION WITH OXYGEN-ACETYLENE TORCH

the fresh metal is applied. All of this will be cared for, if the operator bears in mind that proper union is only to be expected where new and old materials are both molten at the moment of contact.

Consider a typical weld of, say, cast iron. The edges to be joined are beveled off at an angle of 45 degrees, so that a V-shaped groove is formed, the angle at the point of the V being 90 degrees. At the bottom of the groove the two faces of the work are in contact, or nearly so. The very first thing to do is to melt some of the material from the faces in order to seal the bottom, for a distance at least. We now heat the faces, and, if need be, the top of the material just melted down from the

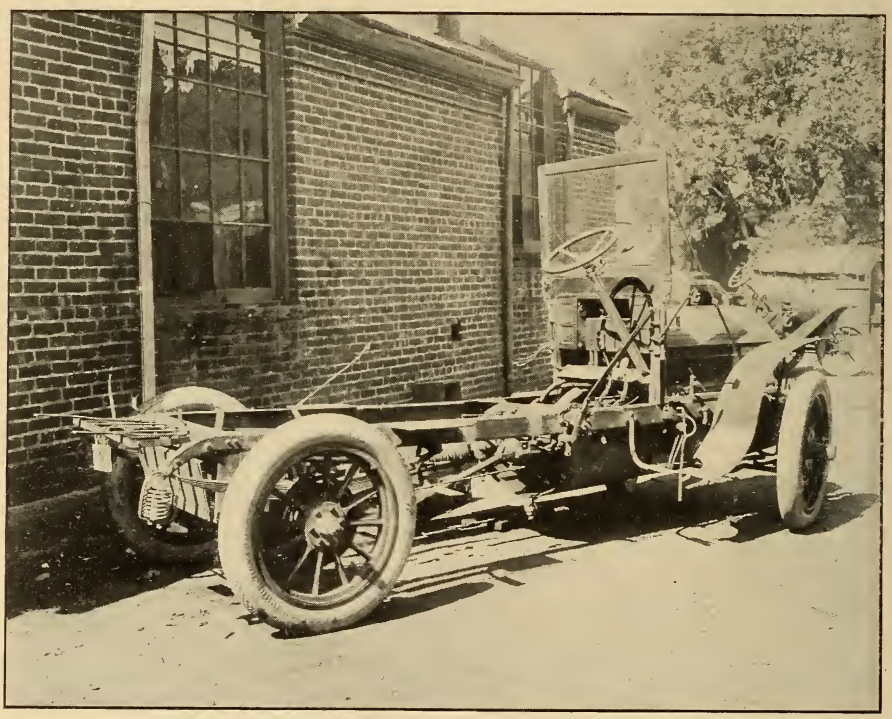
faces, so as to form a molten surface for the attachment of new material. The new metal, in the form of a rod, is now melted onto this surface. The V will thus be further filled up. This process is continued, the workman bearing constantly in mind that the new molten metal must be added to metal that is also in a molten condition.

In heating the surfaces for the reception of fresh material, the torch should ordinarily be so handled as to swing the little working flame round and round in rather small circles, and yet to move slowly onward. In this way the intense heat will be distributed over the desired surface. The object is to melt but not burn. Practice and attention will greatly assist the operator in applying the heat evenly and in avoiding burning.

In handling the rod of new material it is ordinarily advisable to keep the lower end constantly in contact with the work. The object of this is to avoid burning the new metal by providing an opportunity for heat to pass off into the work. Otherwise, the small rod might often become excessively heated. It is the high temperature of the little flame that makes the oxy-acetylene torch so admirable an instrument. The careless workman may, however, injure the new or the old material by not being on his guard as to burning.

Some judgment must be exercised in selecting the size of rod. If the rod is too small in diameter, it will be in danger of being burnt; if too large, the new material may become available so slowly that it will become difficult to keep the surface on which it is to find attachment in a sufficiently molten condition. Good sense will be the guide here.

The size of tip to use will turn largely on the thickness of the work. Heavy metal may ordinarily be expected to carry heat away from the working point. To offset this, the



AUTOMOBILE FRAME WELDED IN THE TWO LIGHT-COLORED PLACES SHOWN

WELDING A 4-INCH PRESSURE PIPE, 1,000 FEET LONG, IN 20-FOOT LENGTHS

WELDING UP A CROSS CONNECTION ON THE BODY OF A PIPE BY THE OXYGEN-ACETYLENE TORCH

ARMATURE RING CONTAINING THIRTEEN WELDS, EACH 1¼ BY 3½ INCHES

larger supply of heat from a larger tip should be brought into service. This will often result in the need for using a larger rod to suit the changed conditions.

To illustrate this point, suppose that sheet steel one-half an inch thick can be advantageously welded by using a certain size of tip and a certain size of rod when we have simply these sheets with which to deal. But suppose the weld is to be made when these sheets are fixed in position with other metal attached beneath the joint. We have here possibilities of increased conduction and radiation. When we seek to get a portion of the work to a melted condition, the heat will be conducted off more rapidly than before, because there is more metal to do it; and, for the same reason, the loss by radiation will often be increased. Other things being equal, a larger tip is the solution of the problem. This carries with it, usually, the selection of a larger diameter of rod. Conversely, we can readily see that conditions might undergo a change requiring a reduction in size of tip and rod. Thus, after trial had shown the sizes suitable, the weight of metal in the immediate vicinity of the joint might be reduced by the removal, say,

of a supporting bar. Clearly, reduction of tip and rod are indicated.

Those who have followed these remarks will have little difficulty in seeing that the welding of free edges and the welding of the same edges held by heavy clamps placed close to the joint are two different propositions. We may learn a lesson in economy here. If we use too large a tip and thus waste oxygen and acetylene, we are, of course, wasting money. Our endeavour should be to reduce conduction away from the working point and thus conserve the heat from the torch. In case work has to be heavily clamped in the immediate vicinity of the joint, it may accordingly often be economical to interpose asbestos or mica; or it may be possible to reduce the actual contact of the clamping surfaces by grooving or corrugating them. Similarly, if the under surfaces at the joint are supported on a metal table or other good conductor of heat, we may often reduce the conduction away from the working point by making a groove or channel all along beneath the joint. Thus, in a certain oxy-acetylene welding machine constructed by the Edison Storage Battery Company a groove is arranged in the metal support beneath the location of the seam. Air is a very good non-conductor, so that if actual support is not needed under the seam it is quite suitable. If support is needed asbestos, mica, or some other non-conductor may be used.

The weld will often be somewhat weaker than the adjacent work. This is sometimes remedied, in part at least, by building up the volume of new material. Metal is frequently added until the upper surface is made convex. Additional attachment may be secured by continuing the excess over to each side of the seam. Of course, the upper surfaces of the work must be heated to a molten state to provide good attachment.

Another method of strengthening the weld is to bevel and weld the edges both from above and below. There will thus be two V's—one above, the other below. The two grooves are dealt with separately, turning the work over for the second weld. Each weld is rounded and material attached to the work by overflowing—as described in connection with the single groove.

It should be mentioned that the beveling of the edges of the work, if of steel, can often be accomplished by the use of the cutting jet. This procedure leaves an oxidized skin. Preferably this should be removed in advance of welding operations. Ordinary steel is, apparently, unaffected beyond this skin. Hard steel will probably experience a reduction in hardness; the carbon content seems to remain as it was. It is important that the edges of the work be clean. If they have been chipped off, nothing further will be necessary. Under other circumstances it may be needful to clean with a suitable acid solution.

The development of the oxygen-acetylene torch is largely due to the work of the Davis-Bournonville Company, of New York, to whom we are indebted for the illustrations of this paper.

RECENT DEVELOPMENTS IN METAL SAWING MACHINES

By Thomas R. Shaw

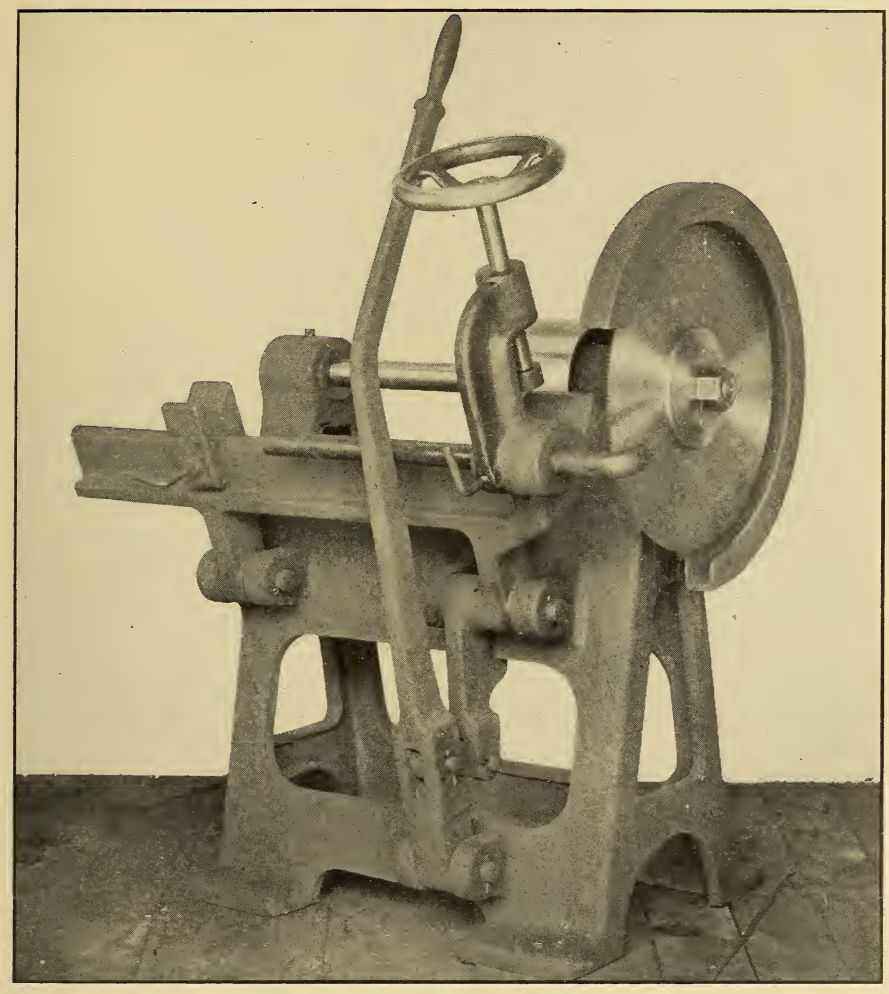
IN the issue of this magazine for April of last year the present writer discussed the extent to which the modern sawing machine for cutting metal has been developed.

The cutting-up of material is one of the items which engages serious attention on the part of those responsible for the efficient administration of the works, and hence some further account of recent machines for this work may be found acceptable.

Cutting-up and cutting-off operations enter into many varieties of work, and the term cutting-off may include almost anything, from the cutting of a bar into two pieces to the cutting off of risers and superfluous metal from castings in a foundry. It is often required to cut from bar stock a quantity of pieces suitable to be made into blanks for spur and bevel gears, rolls, discs, and the like. Bars are also cut into suitable lengths to make short shafts, studs, pins, bolts, etc., and this applies especially to some of the modern shops in which it is the practice to do without a smithy and produce all such parts from the bar instead of from forgings. With the increase in the number of such shops there has come an increase in the demand for cutting-off machinery. The consequence has been a considerable impetus in the development of devices for cutting off all kinds of work.

Cold-sawing is generally conceded to be the cheapest method of cutting-off, since the work may be done automatically; and generally being a rather slow job, such automatic machines require little or no attention. The usual type of cutting-off saw is familiar to all mechanics, consisting of a toothed saw blade mounted on a suitable spindle, supported in journal bearings of standard construction.

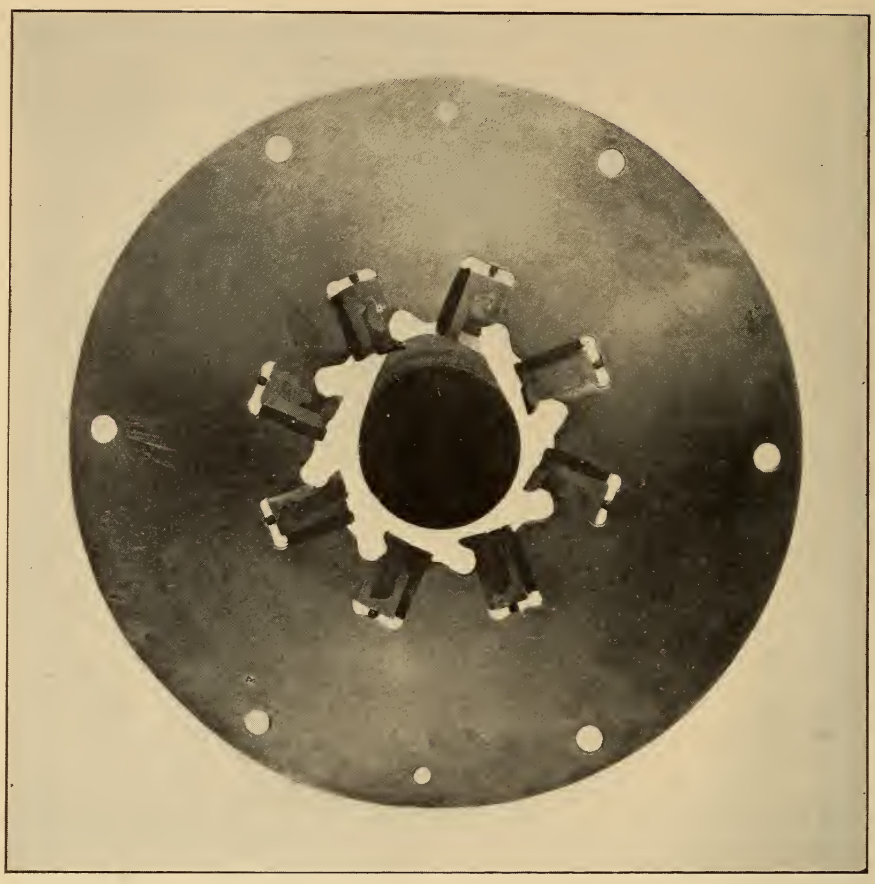
As evidence of the interest which is being manifested in this particular branch of the machine tool industry, we may call attention to two machines of recent design and construction by the Newton Machine Tool Works, of Philadelphia. One of these represents an entirely new departure in the design of machines for this service, being the extreme opposite of the usual type, having the teeth on the inside of the blade instead of on the outside. The bar to be cut is passed inside the blade while it is revolving, and the latter is pulled through the material which is to be divided. The action of cutting with an internal saw may seem strange at first sight; but if a very simple experiment is tried, such as putting a pencil through a ring and then pulling it, some idea will be obtained of the immense possibilities of the device for a quick-cutting tool when provided with cutting edges. As is well known, the "draw cut" is the best method by which metals can be cut, and this method applied to the cold-sawing machine enables a machine to be constructed with the greatest practicable rigidity. The makers claim it to be a more rapid producer than any machine yet made. In a test lasting over several days bars of steel, of 0.40 to 0.45 carbon, 5½ inches in diameter, were cut off in about one minute each. These were experimental tests, and probably



POWER METAL-SAWING MACHINE. BILLINGS & SPENCER CO., HARTFORD, CONN.

heavier than desirable for the teeth to stand for any great length of time; but there is no doubt that the machine will run continuously without any trouble on bars of such stock at feeds almost equal to this. It is important to note that during this test the machine stood on the erecting floor only, and was not placed on a foundation or held down by bolts, as would be the case when installed permanently in a shop.

The blade of this internal saw is 28 inches in diameter over all, and it is accurately fitted to a heavy cylindrical barrel, with which it revolves and to which it is securely bolted. The gap in the centre of the blade is 8 inches in diameter and is fitted with eight removable teeth, allowing a cutting capacity for stock 6 inches in diameter. The inserted teeth are made of high-speed steel, and the method of attaching them to the disc makes them suitable for the heaviest class of work. The teeth or cutters are carried in pockets, or holders, of mild steel, similar in arrangement to those used for other metal saws. The great advantage resulting from the use of the pocket lies in the protection which it affords to the disc in case of accident. Being made of softer material than the surrounding



INTERNAL COLD SAW BLADE. NEWTON MACHINE TOOL WORKS

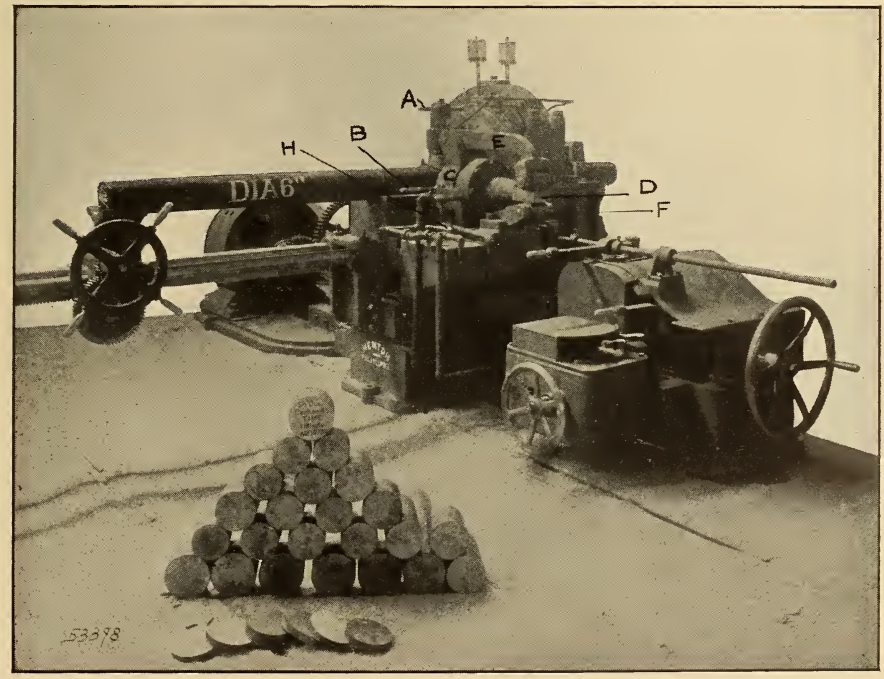
metal, it sustains any shock which may come upon the saw, and, by giving way, prevents injury or breakage to any more expensive part. This method of attachment also permits the insertion of new teeth with greatest ease.

The barrel to which the saw is attached revolves in broad bearings of very large diameter, and is driven by a worm and worm wheel. The teeth of the worm wheel are cut in the solid metal of the barrel, and the driving worm is fitted in the saddle, so that all stresses are self-contained. The worm, of hardened steel, is made of very coarse pitch, insuring high efficiency. It is fitted with roller thrust bearings, and the drive is entirely encased, to permit the gears to revolve in a bath of oil. The saddle is of exceptionally heavy construction, with the base and cap securely bolted together. It is provided with flat bearing surfaces on the bed, with provision for adjustment by means of a taper gib. The feed is provided by means of a screw and a gear box, giving six changes of speed, besides a fast reversing power traverse. The machine is driven by a 30 horsepower electric motor, and there is no other gearing in the drive in addition to the worm and worm wheel except one spur gear connection to the electric motor.

Another special feature of this machine appears in the provision of a powerful clamping device capable of holding a bar with sufficient firmness during the cut and yet easily controllable by the operator. For this

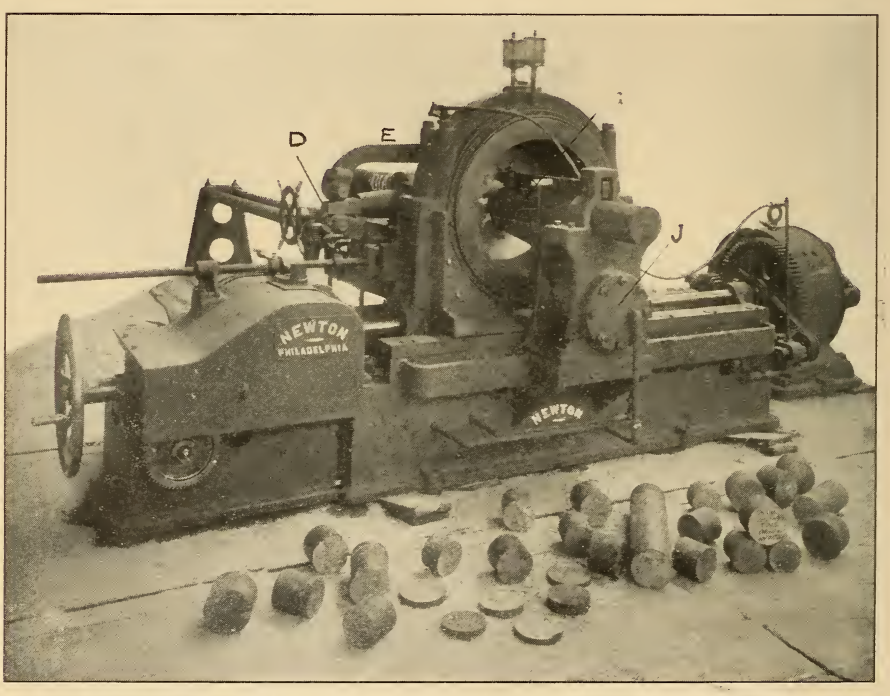
COLD SAWING MACHINE WITH CONCAVE BLADE. NEWTON MACHINE TOOL WORKS, PHILADELPHIA

purpose compressed air is used to provide the necessary power, so that the clamping and releasing are done without the necessity for any exertion on the part of the operator by the simple movement of a regulating valve. Another device to aid in obtaining rapid production with the machine is a trolley, which carries the ends of long bars and serves to bring them forward rapidly after each piece is cut off. In operation, the trolley is adjusted to the outermost position on the guides, and a long bar is lifted into place. The clamping screw *A* is adjusted by hand until the

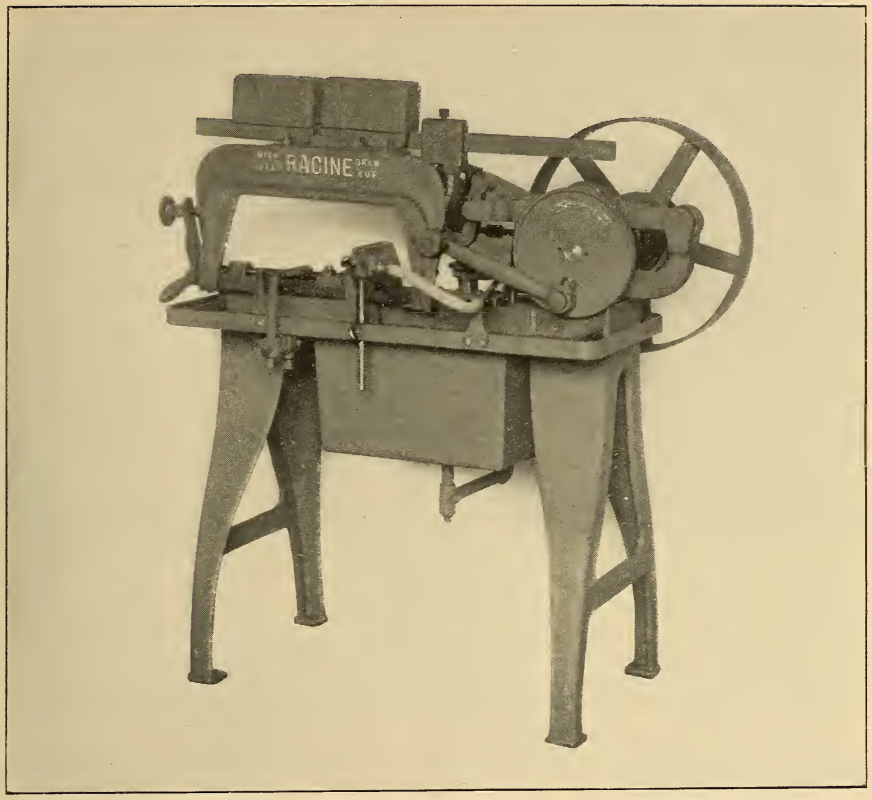


REAR VIEW OF INTERNAL COLD SAWING MACHINE, SHOWING PNEUMATIC CLAMPS AND STOCK TROLLEY

REAR VIEW OF NEWTON CONCAVE BLADE SAWING MACHINE



INTERNAL COLD SAWING MACHINE. NEWTON MACHINE TOOL WORKS, PHILADELPHIA

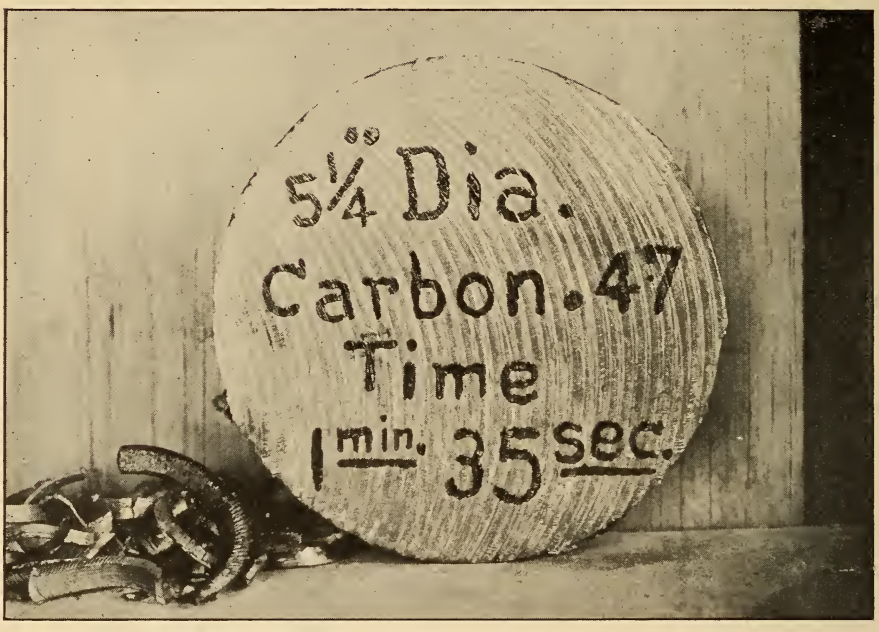


RECIPROCATING HIGH-SPEED METAL-CUTTING SAW. RACINE TOOL & MACHINE CO., RACINE JUNCTION, WIS.

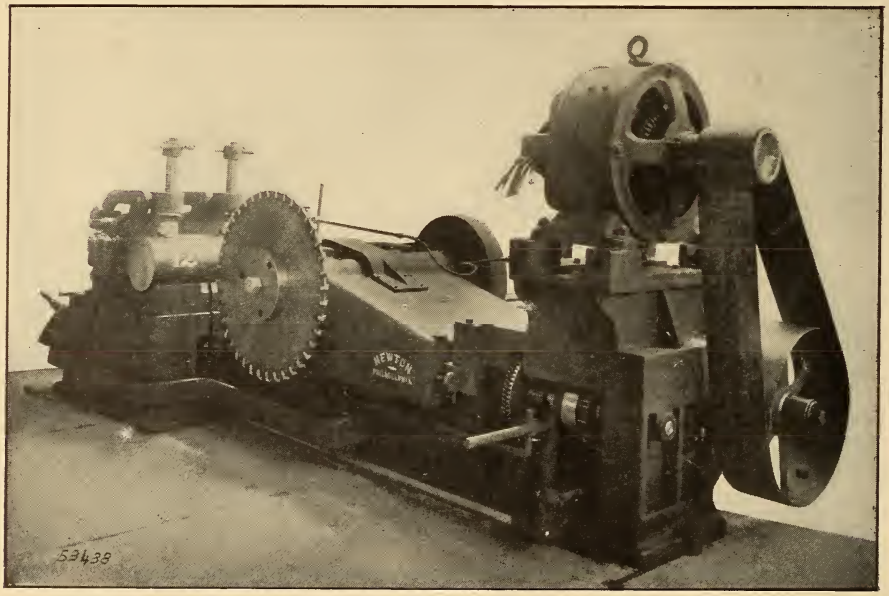
V-block underneath comes in contact with the work. The lever *B* is then operated to admit the compressed air, and this, acting on a piston inside the cylinder *C*, forces out the piston rod. On the end of this is a flat piece *D*, the lower part of which is parallel with the rod and the upper part tapered. This acts as a wedge and forces open the end of the lever *E*, and as this carries the clamping screw *A* on the opposite end, a very great clamping pressure is put on the bar. The roller at *F* is stationary, and serves to take the pressure due to the reaction of the lever. To release the clamp, air is applied to the piston in reverse direction. An additional air-controlled device is placed on the other side of the machine to hold the piece which is cut off from the bar at *G*, thus preventing it from falling into the saw blade when the saddle is returned by the fast traverse for the succeeding cut. The lever *H* controls the operation of this cylinder *J*, and the arm connected to it holds the metal cut off.

Another machine by the same builders is of the ordinary type of external saw, but has embodied in its design a number of novel features, chief among which is the provision of the air clamp and trolley, as with the internal saw. The use of modern high-speed steel teeth permits greatly increased production; but even with suitably heavy machines much time is consumed in setting up for successive cuts, so that the above attachments tend to increase the total efficiency of the machine.

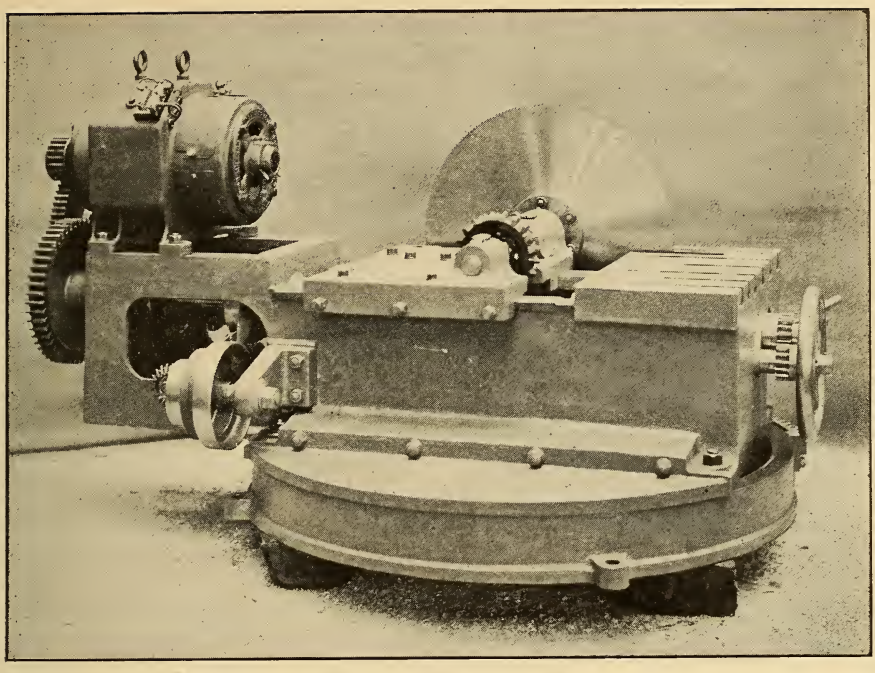
The principle of the draw cut has also been applied to cutting-off saws



SECTION OF BAR AND CHIPS CUT WITH NEWTON CONCAVE-BLADE SAWING MACHINE



MASSIVE COLD SAWING MACHINE WITH PNEUMATIC CLAMPS. NEWTON MACHINE TOOL WORKS



FLUSH SIDE COLD-SAWING MACHINE

of the reciprocating type, and one of the illustrations shows the Racine high-speed saw of this type. This machine is provided with an automatic lifting device, consisting of a hardened steel cam, roller, ratchet-bar and dogs aranged to avoid dragging back by lifting the blade on the return stroke. A cooling compound is kept on the blade by the action of a circulating pump, and the machine is capable of being operated at 125 revolutions when cutting soft steel or 90 revolutions on tool steel.

LOOKING FORWARD

EDITORIAL NOTES ON IMPENDING DEVELOPMENTS

The Law of Perfection

There are many relations among physical forces and quantities which have been derived from observation and experiment, and these, in the hands of thoughtful investigators, have furnished most valuable results. In many instances, however, such laws are not applicable until after the event, and thus are not of material value as rules of conduct. In this respect the practical man is in much the same plight as the business man, to whom judicial authorities have said, in effect, that he must go ahead as best he can, and that he will be told afterwards whether he has violated the law or not.

There are some laws of nature, however, which may be interpreted in such a manner that some indication may be had in advance as to the results which will follow, so that the careful investigator may receive some kind of guidance in his work and not be compelled to act wholly in the dark.

Among such rules of conduct there appears to be one to which little attention has been directed, but which seems to be impressed by the conduct of past affairs, and which, if verified, should prove a very useful guide to undertakings under consideration. This, for lack of a better name, we may call the "law of perfection."

In brief, this law, if such it be, is to the effect that when any industry, art, method of manufacture, social relation, or the like, is seen to be approaching to a complete solution, so that little room appears for further perfection, then that same industry or art is on the verge of complete and sudden replacement by something else of an entirely different character. Under this rule it seems that an industry or art does not reach a maximum of development and then remain on a high plane of success until it is gradually superseded by something else; but rather, it drops from a high peak of effectiveness to zero and its successor is something either unforeseen or something so different as wholly to preclude the successful continuance of the older method.

Examples of the operation of this law will readily suggest themselves to the observant reader, and it is necessary to call attention to but few of them. The replacement of the stage coach by the locomotive; the supercession of the ship-of-the-line by the steam-propelled ironclad; the invasion of the field of the steam engine by the combustion motor; the rise of the automobile, and the coming of the aeroplane—these are but a limited number of instances. Nearly every city has seen the manner in which some favoured locality for commerce or residence has reached the pinnacle of favour, only to drop into decadence, while some previously ignored place takes on the preeminence. In politics, in government, in social relations as well as those of industry, it will be seen that the steady approach toward a high degree of completion is quickly followed by the interposition of something to which but little attention had been given, but which, with remarkable celerity, takes the place of the method, art, or position holding the favoured point of supposed advantage.

If this be a law, and its claim to that status seems worthy of examination, it may be desirable to consider the extent to which it may be employed as a guide in the conduct of many undertakings. It would be of small advantage to expend time and effort in the final perfection of an art or appliance which was shortly to be superseded, while it might be very desirable to be able to grasp the relative endurance of different methods and appliances before determining the extent to which it might be expected to endure. In any case, it is desirable to have the possible existence of such a law in mind, and to compare its indications with the relation of events which have already occurred to those which may be impending.

Military Conservatism

It has been said that there is no more conservative individual than the old soldier, and history is full of examples of the tardiness with which the military man falls into line and accepts changes which others have perceived long before. The armoured knight failed to accept the advent of firearms with about the same degree of persistence as the naval officer of five hundred years later regarded steam power and armoured ships; and the objections of the old Austrian officer to the tactics of Napoleon, because he fought battles in December, were quite in the same line of thought.

Now we have a similar condition of affairs in connection with the development of navigation through the air. It is evident that every army or navy man who discusses the advent of the military aeroplane or dirigible does so either with disapproval or with such limited appreciation as accompanies the advent of a new arm which originated in civilian efforts.

This is clearly shown in the fact that the United States War Department has assumed that two types only are under consideration. One of these—the "speed scout" aeroplane—is intended to carry a single operator, and to be used for the rapid location of large bodies of troops; the other, a general scouting machine, is expected to carry two men, who are to make general observations, take photographs, make sketches, detect small bodies of men, and do similar work. That is, the limited grasp of the War Department sees in the aeroplane nothing more than an auxiliary to the present antiquated method of settling international disputes by the manœuvres and combats of armies of men operating upon the surface of the earth, and utterly ignores the fact that there is coming into existence a method of fighting which is to render existing armies and their operations as obsolete as the elephants of Hannibal or the chariots of Alexander.

It has been said that if, at almost any period in the history of engineering development, any one government had had the initiative to take up immediately, in advance of other nations, the devices which were openly placed at their disposal, the rest of the world would have been rendered helpless. This was true when Fulton vainly urged Napoleon to accept the steamship and the submarine torpedo: it was true when Ericsson was made the butt of ponderous naval jokes; it was true when electricity was first suggested for naval service; it is true to-day when the possibilities of the aerial fighter are properly considered.

The fact that, instead of acting merely as an auxiliary, as a scout to the aid of an army on the surface, the properly powered and equipped aeroplane or dirigible will leave all armies and navies behind it and speed to the capital of the enemy, to destroy utterly the men and machinery of government, and to wipe out the centres of finance and industry, does not seem to have occurred to these estimable gentlemen; and their

objections to such a method of proceeding will doubtless take their place along with those of the men who disliked "villainous saltpetre" a few centuries before. Already speeds of more than a hundred miles an hour have been attained, and speeds of two hundred miles are under consideration. Engines of 100 horse-power will soon be replaced by those of five or even ten times that capacity, and instead of one or two scouts the machines will carry full crews, armed with high explosives and weapons for distributing fire and suffocation to all beneath. Whether this will result in a return to barbarism, or whether it will mean the abolition of all warfare, remains to be seen. One thing at least is certain: it means the utter disappearance of the obsolete armies and navies whose chiefs are now deciding that the new weapon may make a useful scout or a convenient auxiliary to their antiquated apparatus. That the decision will probably be made by some rank civilian is a matter which will appear rather irrelevant in the light of existing conditions.

Burning Raw Coal

For a long time the smoke problem has been under investigation, both on the part of manufacturers who have produced the smoke in the course of power generation and on the part of the public and the local authorities in various places who have endeavoured to secure the abatement of the nuisance. There is now under way, in the hands of the department of industrial research of the University of Pittsburg, a scientific study of the subject, from which important results may be expected. The fact that this work is going on at Pittsburg, where, in the words of the preliminary outline of the investigation, "the smoke problem is the greatest civic problem" confronting that city, and also the fact that the work is under the charge of Dr. Robert Kennedy Duncan, as director of the department, gives every assurance that valuable results will follow.

That there is abundant opportunity for a successful solution of the smoke question is a matter about which there can be little difference of opinion. The production of heat by the combustion of coal, whether for power, metallurgical, or household purposes, is an operation which has, until very recently, been conducted in a manner hardly in accordance with the progress which has been made in other departments of applied science. Apparently coal is one of the few natural products which is still used very largely in the crude or raw condition. We have long since ceased to use rough logs or rough, undressed stone for building purposes. Nearly every other mineral product is, either voluntarily or of necessity, subjected to operations of purification, separation or improvement before it is applied to its main purpose. Liquid fuel is passed through an elaborate series of refining processes, while many other examples might be cited to show how fully the desirability of getting away from the raw condition is understood in most departments of industry and utilization. In the case of coal, however, apart from the crude operations of picking and sizing, very little has been done; and with the exception of the conversion of certain kinds of coal into coke, in order to obtain a fuel free from sulphur and similar impurities for metallurgical purposes, the principal fuel in existence is burned in a raw condition. That it should not be burned to advantage under such circumstances is hardly surprising. Far more surprising is it that the use of raw coal should so long have continued, when associated with kindred operations toward which the best abilities of the ablest scientists have been directed for refinement and differentiation of applications.

If we could assume that crude oil was burned for purposes of illumina-

tion, and the production of smoke under such circumstances should long be permitted, and that finally a scientific body should undertake to discover how this production of smoke might be prevented, we might have an analogy to the present situation in connection with the generation of heat by burning raw coal.

The outline of the smoke investigation, as contained in the bulletin issued by the University of Pittsburg, includes an examination of the influence of smoke upon vegetation; a study of the chemistry of smoke and soot; a discussion of the physical problems of smoke; of the injury to buildings; the effect upon health; the cost, and the sources of smoke. These are all interesting details of the problem as it stands, and there is no doubt that their study will result in the accumulation of most valuable information. At the same time, it seems as if they were dealing with results rather than with causes, and that any final solution of the question would necessarily go back to the other end of the subject—to the refinement of the fuel before any attempt at the efficient combustion of its constituents were attempted.

The development of engines capable of using liquid fuels directly in the cylinder, beginning with the lighter and more volatile constituents of natural liquid fuels and passing to the successful and highly efficient combustion of the heavier oils, has now reached a point where the tarry liquid produced by the distillation of coal is readily available. Apart from the enormous supplies of natural liquid fuel suitable for power generation in the combustion engine, this fact indicates the solution, not only of the efficient power-production question, but of the much deeper matter of the abandonment entirely of raw coal and the general introduction of methods of refining it similar to those long since used for refining oil.

Instead of shoveling raw coal into a furnace in which it is burned with insufficient contact with air and in close proximity to cooling surfaces hindering combustion, the method of the future will appear in some form of gasification, taking the coal in its raw condition and separating it into fixed carbon or coke, as well as gas, tar and useful by-products. Of these constituents, the coke is available for smokeless combustion, both for household and for metallurgical purposes; the gas and the tar are both capable of use at maximum efficiency in their respective types of combustion engines for the generation of power, while the ammonia has a well-known value in agriculture. It has been estimated that the liquid and gaseous constituents used in the highly efficient engines now available are capable of providing as much effective power as was formerly generated by the combustion of the entire quantity of raw coal, leaving the coke and ammonia as recovered wastes, the smoke problem disappearing altogether in the course of the more rational use of the coal. No less an authority than Dr. Rudolph Diesel has stated that the production of tar in Germany is sufficient for the generation of one and three-quarter million horse-power, leaving all the fixed carbon of the coal available for other purposes, besides the gas.

Under such circumstances the use of raw coal as fuel is about as intelligible as would be the use of raw meat for food, or the employment of raw skins for clothing.

Display Lighting

One of the things which has apparently yet to be learned in the use of electric lamps for display signs and similar purposes is the efficient use of the light and the avoidance of waste. The old idea that a good thing might be made better by using more of it is still evidently the guiding element in the design and construction of electric signs, and the

result is such an excess of brilliancy as to defeat, in many instances, the entire object in view.

A sign may be planned carefully, and executed, so far as construction is concerned, entirely in accordance with the plans of the designer, and then filled with incandescent lamps in such profusion and of such brilliancy as to produce little more than a confused glare in the eyes of the spectator and a correspondingly disagreeable impression upon his mind. A general mass of shifting lights and brilliant clusters of incandescent lamps may produce a "White Way" effect and provide a far more brilliant illumination for a street than would be considered practicable for any municipal lighting installation; but few of the individuals who are paying for this indiscriminate brilliancy realize the extent to which their efforts to outdo each other result only in a general optical confusion, in which all definite publicity is lost. This means, not only that the ultimate effect of all this display is interfered with, but also that far more expenditure of electrical energy is made than is needed to produce a much clearer display.

If a given sign were fitted with incandescent lamps of high efficiency and brilliancy but of much lower individual candle-power than those now employed, and if, also, these lamps were spaced somewhat farther apart, the result would be far more distinct and legible to the spectator, and such a sign would stand out clearly and intelligibly in the midst of the brilliant blur of its surrounding disturbers of the optic nerve.

Mechanical Traction

During the heated season, in one of the great cities last summer, some comment was made upon the fact that fewer horses than usual had succumbed to the effects of the heat; but the explanation was promptly forthcoming that this was due to the fact that fewer horses were employed, and that the extent to which the automobile and the motor truck had replaced the horse-drawn vehicle was thus clearly indicated.

It has been assumed that, while the motor vehicle will undoubtedly drive the horse almost entirely from great cities, in the country it would still be found that animal traction would long persist.

This idea is rapidly passing, and in the country the automobile is found on every road; and, furthermore, the mechanical tractor is displacing the horse from the farm. Farming has been behind nearly every other kind of work in the substitution of mechanical power for human and animal effort, and the hard life of the farmer has long been a subject for discussion; but this distinction is rapidly passing, and to-day the applications of manufactured power to agriculture are seen on all sides.

At points within the reach of economical electrical transmission from power centres the use of the electric motor is entering into the transformation. Where electrical current is not available, the internal-combustion engine, preferably using ordinary kerosene as fuel, is employed, not only for hauling plows, harrows and cultivating machinery, but also relieving the farmer from nearly all of the heavy muscular effort formerly so onerous.

When the farmer has no longer to devote a large part of his own labour and a considerable portion of his crop to the maintenance of the horses to do his work, and uses instead a modern power machine of highest efficiency, consuming the most convenient and least expensive fuel, there must appear a large increase in the general efficiency of agricultural operations. If to these advances there is added the application of modern intensive methods of cultivation, there should result a much higher production per acre, without demanding the services of a greater number of men, so that the efficiency, both of the farmer and of his land, will be increased.

It has been estimated that, in the United States, it will be necessary to increase the product of each acre of land by one per cent. each year to meet the increase in population, and that the average wheat yield of 14.8 bushels per acre, as in 1909, must be raised to 17.8 bushels to meet the demand of twenty years hence. In view of the fact that the average yield per acre in Great Britain is 33.1 bushels, there should be no difficulty about doing this, provided the labour conditions can be met. It is probable that the great farms will gradually be brought under conditions of business operation similar to those which have been found essential to the development of other departments of industry, and we shall probably see the great food staples produced very largely by the aid of machinery, controlled by corporate management, in a manner similar to the development of other natural resources, such as minerals, hydraulic power, and the like.

Rail Inefficiency

There is probably no piece of mechanical construction which is operated under conditions leading to inefficiency in a greater degree than the much-abused railway rail. Originally designed for moderate service, it has been loaded past endurance again and again, and the only way in which its development has been attempted is to make it stronger and better able to endure the hard burden which is laid upon it. Heavier weight, improved section, higher-grade material—all have been used to enable the rail to stand the loads and impact effects which railway development is placing upon it in continually increasing degree, but it seems hopeless to expect that the demands for heavier service will be abated, so long as the rail is improved to meet them.

It would seem that there is here an opportunity to apply the well-known principle of reversal, and instead of discussing methods for improving the strength of the rail, to see if something cannot be done to use it a little more rationally and efficiently. The thoughtful man, standing by the side of a great trunk railway line, looks at the track and realizes that it is subjected to deflections and hammer blows almost past endurance as the heavy train thunders past; and then he considers that, until the next train comes, the entire roadbed is lying there idle.

The steel girder, made of similar material and in similar manner to the rail, is placed in a great building and carefully loaded to a point well within its elastic limit, and there allowed to remain, continually under service of almost uniform character, and in a position to deliver an efficiency of very nearly 100 per cent. The rail soon gives way under its unequal task, while the beam performs its unseen duty indefinitely.

It is certainly impracticable to use the rail under conditions similar to the beam, but at least some effort might be made to approximate more nearly the conditions which make for higher efficiency. What is needed is not to make the rail stronger and more enduring, but rather to put upon it a load of more continuous character and less violent fluctuations. The object of the railroad track is to provide a way for the transport of merchandise, both animate and inanimate, and it is the total capacity of the road which is to be considered. If, therefore, instead of increasing the weight of locomotives and trains past endurance there were installed an entirely different system, using the continuously operating conveyor as its fundamental principle, the capacity might well be increased almost indefinitely, while the burden upon the rail would be changed from an intermittent pounding to a nearly uniform loading of very moderate unit stress.

It is evident that this method can hardly be applied under the present system of hauling heavy trains by

ponderous steam locomotives, and it would seem that in the rail problem alone we have reached a point where some other method, permitting of a continual instead of an intermittent action, has become altogether desirable. Probably the true solution of the problem will be the substitution of electric traction altogether for that of the steam hauling engine, permitting the substitution of one or two self-propelled cars at frequent intervals instead of the time-honored train, and thus subjecting the rails to more frequent loads of lower magnitude for the heavier blows of the present system.

The ideal method of transport would undoubtedly be that of which the traveling platform is the crude forerunner—a wholly continuous movement with auxiliary slower speeds at points where the main transport system is to be boarded. This would substitute continuous motion of moderate speed for an intermittent movement of higher velocity at intervals, affording a gain in ultimate duration of journey and the replacement of impact stresses by uniform loading.

It is too soon yet to indicate the transport system by which the present railway train service is to be superseded, but the perfection to which the latter has attained is an indication that it is approaching the time when its successor may be expected. It is more than probable that the new method, when it appears, will include the entire separation of passenger from merchandise transport, and that the former, when necessary, will be made through the air and the latter by some continuous system, similar to the belt conveyor in principle, modified by the manner in which industrial operations are conducted.

It has already been pointed out in these pages that there is a vast amount of personal transport which is probably to be superseded by apparatus which will enable the unnecessary movement of individuals to be replaced by simpler conveyance of material and personality, so that it is altogether possible that transport methods may become taxed less and less, so far as individual passengers are concerned, while merchandise transportation will be modified along the lines indicated above. Under such circumstances the much-abused rail will be operated under conditions which should permit a high efficiency of service to be furnished, instead of the present rather crude and violent method.

A Matter of Precedent

The hampering influences of preconceived notions and of precedents which should really have but little consideration are often responsible for certain curious conclusions which would otherwise never occur to a thinking man for a moment.

Thus, for example, the fact that men have in past ages been employed largely by the day has led to the idea of a day's work. When it was found desirable, in modern manufacturing operations, to use the hour as the unit of measurement in dealing with employees, the old idea of the day still persisted behind the later practice, although it had really lost its position, except as a matter of custom. The result appears in some discussions of labour questions in connection with such work as that involved in the iron and steel industry, where the processes necessarily involve the maintenance of continuous operation. A blast furnace, and all the equipment which deals directly with its product, must be kept going continuously until the furnace is "blown out"—an operation which does not take place more frequently than at intervals of two or three years. This means that the men by whom the work is done must operate in successive "shifts," relieving each other in much the same manner as is done by the "watches" of the seamen, engineers, stokers, etc., on an ocean steamer, where, again, for obvious reasons the machinery must be kept in continuous operation.

In times past the work at the steel mills has been done in what is called two shifts, of twelve hours each, the twenty-four-hour day being divided into two equal parts. It is recognized that twelve hours is too long a period for men to follow such exhausting work, and yet it has been seriously maintained that the only alternative is to substitute three shifts, of eight hours each, dividing the twenty-four-hour day into three equal parts. This is stated to be too great a jump, from twelve hours to eight hours, and yet it has been almost universally assumed that there is nothing else which can be done, the wholly unjustifiable assumption being tacitly made that the number of working hours *must* be a perfect divisor of the number of hours in a day. As a matter of fact, the use of the hour as a unit of measurement wholly supersedes that of the day, and there is no more necessity for considering the day under such circumstances than there is in requiring the dimensions of any part of a machine, stated in inches, to be an aliquot part of a foot.

Suppose, for instance, that it should be decided that a nine-hour shift would be acceptable to employers and men in such a continuous job as iron making. The only result, so far as the day is concerned, would be that the third shift would overlap three hours into the second day and six hours into the third day, and that there would then follow a rotation of day and night periods for the three shifts of men, so that there would be eight shifts in the course of three days, or 72 hours, and that the whole system would repeat itself every eight days. Apparently such a rotation would be more desirable, both from considerations of health and of efficiency, than any equal division of twenty-four hours which would keep the same party of men regularly upon night work while another gang worked only in the day time. On shipboard the so-called "dog watches" are inserted for the very purpose of shifting the day and night watches equably through the crew, and yet the desirability of such an automatic shifting seems to have entirely escaped the employers of labour in other forms of industry.

Another example of the influence of custom against an obvious reform appears in connection with the plans which have been suggested to make a better utilization of the hours of daylight, by shifting the activities of life according to the season in such a manner that the bulk of the work of mankind should be done while the sun is shining. The desirability of such a plan does not seem to have been very seriously questioned, but various objections have been urged on the ground of interference with customs and habits which, in themselves, have little or nothing to recommend them.

In warm countries, where it is desirable to avoid hard work during the hotter portions of the day, a reverse method has been very generally adopted, and the *siesta* of the Spanish-American countries is offset by the early rising and utilization of the cooler morning hours for work which would be impracticable under the hot midday sun. The essential thing about any such arrangement lies in its general adoption, as otherwise it would be impossible for any concerted action to be effectively conducted.

An instance of the influence of convention in machine design appears in the steam locomotive. The first engines were so low and small that the driver had no difficulty in seeing the track over the boiler, even though the slender smokestack was before him; and the conventional arrangement thus employed for the early locomotives has been generally continued, notwithstanding the fact that the modern immense engines obscure the view to such an extent as to make some other plan most desirable.

It is true that some locomotives have been built with the cab for the engineer in front of the boiler, and

in the electric locomotives thus far constructed the engineer is generally placed in the middle of the machine, with a clear view either forward or backwards, or, rather, with the locomotive alike at both ends. The designs for the new Diesel locomotive, using liquid fuel in Diesel combustion engines, have also broken away from the older steam locomotive conventions, and some of the recent special steam locomotives have the cab placed on top of the boiler, so that a better view of the track may be obtained; but, in general, the force of custom has been so great as to cause most locomotive designers to adhere to an ancient arrangement when the obvious thing would be to do just what the electrical engineers did in the first place and put the engineer where he would get a full view of everything in front of the train.

In all such plans for the increase of efficiency the necessity for considering each question upon its merits and divesting the mind from the hampering influences of precedent must be kept continually in mind. By selecting the controlling elements of an operation, the things which it is desired to accomplish and the limitations which must positively be observed, it will usually be found practicable to cut loose from many hampering conventionalities and clear away sources of waste and impediments to efficient operation.

THE CONTROL OF FIRE IN MINES

UNITED STATES BUREAU OF MINES

AMONG the various attempts to reduce the losses in coal mining operations, and thus effect the conservation of fuel supplies, there is probably nothing more important than the control and extinguishment of the disastrous fires which are continually occurring below ground. The United States Bureau of Mines has taken up, and is still continuing, an investigation of this question, and in a report which is called a preliminary study of the subject, prepared under the direction of Dr. Joseph A. Holmes, by Mr. George S. Rice, some most valuable suggestions are made. In the following pages an abstract of this report is made, while those who desire the full study are advised to communicate with the Department of the Interior for a copy of the complete document.

Mine fires, like most other fires, start in a small way, only excepting those starting from explosions of gas or coal dust. A large proportion of them, like other fires, are caused by carelessness, particularly in metal mines. In coal mines and in some sulphide-ore mines fires may originate from spontaneous combustion in the goave, yet even such a cause often may be attributed to improper and preventable conditions, or to a wrong system of mining.

Most of the mine fires that have occurred in open workings could have been quickly and easily extinguished at the beginning had suitable apparatus and men trained in its use been at hand. A considerable proportion of such fires would not be possible if fireproof material were systematically used in underground construction. But at present it is commercially impossible to do away entirely with the use at mines of combustible material like wood timbering. Hence, arrangements should be made to lessen the chance of fires starting, and apparatus should be provided so that if a fire does start it may be put out promptly.

With the exception of explosions there is nothing that causes such dread among miners as a fire. There is not only danger to life, but also danger of great financial loss. Each year the mining bureaus of almost every mining State report the death of men and the shut down of mines by fire, and sometimes the permanent loss of the mines and equipment. These fires do not attract public attention unless there is large loss of life.

Fires that destroy large areas of valuable coal are sometimes started at the outcrop where the coal is exposed naturally or by prospect holes and quarrying. Such fires are sometimes started by camp fires or even by carelessness in near-by mining operations. The extensive Carbondale, Pa., fire is said to have been caused by dumping ashes from a boiler plant upon an exposed outcrop. When the fire starts, as in this instance, in coal beds that have been partly mined, its progress is very rapid. Obviously, had a fire, starting as the Carbondale fire is reported to have started, been attacked immediately, a few barrels of water would have put it out.

In the arid regions of the country, as in Colorado and Utah, vast areas of outcropping coal were destroyed in prehistoric times, and coal beds may be fired to-day at an outcrop by camp or forest fires. It should

be the clearly defined duty of owners or of State or Territorial authorities to attack and put out these fires promptly, although there may be no mines in the neighborhood.

Fires rarely start in shafts, because they are generally damp or wet. In slopes or drift entrances fires are as likely to occur as in any mine passage or level, with greater danger if the slope or drift is timbered and is connected with outside buildings.

Special fire risk is attached to shaft landings or "bottoms." Here the coal cars are run on the cages or the ore cars are dumped in the skips. The cagers, trip handlers, and drivers, or, in metal mines, the trammers, gather here. Also, when changing shifts, many miners gather at these landings. If open lights are used in the mine, some miners, while they wait, change the wicking of their lamps. The discarded wicking or pieces of cotton waste used for cleaning the lamps are often thrown into some corner in a smoldering condition and thus serve to start a fire. If it is a metal mine, in which candles are generally used, the candle ends are liable to be thrown or dropped with smoldering wicks into some corner where there is material that will burn. Frequently there are boxes, storage cabins, or underground offices near the shaft bottom or landing. It is a common thing to line these with wood and to place in them boxes that contain combustible material. If men bring open lamps or candles or are allowed to smoke tobacco there, danger is constantly present. It has been observed by engineers of the bureau that on the wood landings in certain metal mines, candles in holders with tin sides but open bottoms have been left burning when there was no attendant. When the candle burns down, the end of the wick drops to the floor; the shield guards the flame, but does not prevent the fall of the burning wick.

If possible, brick or concrete linings, or "steel timbers," with as little wood as possible, should be used at shaft bottoms or landings. There should always be a water main large enough to supply several streams of water near the shaft; this main should be not less than 3 inches in diameter. The water pressure is of great importance. The informal experiments made at the Chicago laboratory of the National Fire Underwriters' Association proved that one man unaided can not control easily a 1½-inch hose with a smooth cone nozzle of ½-inch diameter when the pressure is from 40 to 50 pounds; on the other hand, to throw the stream far enough to be of value, the pressure must be not less than 20 pounds per square inch (46-foot head).

A pressure of 20 pounds is easy to obtain; the usual difficulty in shaft mines is to control or keep the pressure down to 50 pounds. This control can be had by an automatic reducing valve at the foot of the shaft-column pipe, but such a device is open to the objection that it is liable to get out of order. Another method of controlling high pressure is to open very slowly the valve at the hose attachment. Unfortunately, in the haste of the moment, the valve is liable to be opened too far, and the hose becomes uncontrollable. A third plan, more expensive than the others, but more certain in deep shafts, is to place a tank or sump 90 to 100 feet from the bottom of the shaft, thus obtaining the desired pressure of about 40 pounds. The water-supply pipe from the surface should discharge into the tank, in which a float should automatically close or open a valve in the column pipe. Obviously, for winter use such a tank must be placed in an upcast or in a neutral shaft to avoid freezing.

For fighting fire underground there must be mains from a surface supply down one or more of the shafts, unless the drainage water of the mine can be used, but whether supplied with surface or drainage water, the mains must be ready for any

emergency, being kept full of water all the time and connected to a tank or reservoir on the surface to obtain a natural head. The emergency supply should be not less than 5,000 gallons, preferably much more. In districts that have cold weather, to prevent freezing, either the water must be warmed or the water column must run down the upcast shaft.

Water taps not more than 100 feet apart should be provided along the landings or main bottoms. The water pipe and taps, if not extended throughout the mine, should be in all the passageways in the vicinity of the shaft or shafts, and along the main roadways for several hundred yards. As previously stated, the water main should be not less than 3 inches and the branch lines not less than 2 inches in diameter. In a coal mine the taps can be used in wetting down coal dust.

Reels of 50-foot lengths of 1½-inch hose with nozzles attached should be placed in recesses or in portable boxes at intervals of about 200 yards, and there should be at least three such reels at easily accessible points in the immediate vicinity of the shaft.

Where shafts or shaft bottoms are lined with wood and are connected by a cross passage, it is important that this passage have at least three doors, preferably steel, hung in brick or concrete frames. Such doors prevent fire in or near one shaft short-circuiting to the other shaft.

Generally there are underground pump rooms and engine rooms in which oil and waste must be used. If steam is the source of power, the danger of spontaneous fires from oily waste, through heating and drying, is much increased.

It is folly to build such inclosures of wood and to allow storage of any combustible material, except what is required for a day. Often no attention has been paid to the dangers incurred and many serious mine fires have resulted, one of which occurred recently.

In all pump, engine, and motor rooms there should be metal-covered boxes for waste, and also some sand to throw on the waste in case of fire. The waste boxes should be emptied two or three times a week.

All motor, generator, or transformer rooms should be arched and lined with a non-combustible material, such as brick or concrete, and should be floored with cement. The entrances should have fire doors, so that serious fires can be shut in if necessary. Fire may result at any time from short-circuiting, and ignited insulating material may make a dangerous fire. A supply of sand should be kept in buckets for use in putting out such fires.

In pump rooms and engine rooms where machine oil is used, only enough for one or at most two days should be kept. It should be in cans and locked in non-combustible boxes in which no waste or other material is placed.

In many mines, especially in coal mines with shaft openings in which the cars are "caged" on one landing or "bottom," oiling or "greasing" the car wheel bearings is done underground.

The black oil for this purpose is often left in open barrels at one side of passing tracks, and the oil can or squirt gun is filled from the open barrels. If the barrels are exposed to the intake air in winter the oil tends to freeze; as a result pails of oil are sometimes warmed by torches. When the oil is thus left exposed, and open-light torches are used by the men in the vicinity, the oil is liable to be set on fire.

Wherever feasible, car oiling should be done on the surface. If oiling on the surface is not practical, the oil should be kept in a fireproof room with cemented floor and an emergency fire door of steel plate.

If the oil requires heating, this should be done by hot-water coils; if steam is used the pipes should not be in direct contact with the oil. A drip pan should be used and frequently emptied.

The oil room should be lighted with protected electric lights or with safety lamps. No open lights should be permitted within the inclosure.

A supply of dry sand and buckets of water should be kept at hand to put out a fire that might start in spite of the precautions taken.

Fires in stables are especially dangerous. The speed with which fire spreads in loose hay or straw aided by the usually large amount of wood or timber present makes such fires hard to fight. Stables should not be lined with wood; they should be arched, and the partitions and stalls should be made of iron or concrete. Supplies of baled hay and straw should be brought into the mine in small quantities and then only when wet or covered with wet tarpaulin. The hay or straw should be stored in a separate inclosure behind locked doors or grating. Straw, hay, and other material that will burn should be taken into the mine on that shift which has the smallest number of men.

In several handy spots in and near the stables there should always be hydrants and coils of hose. If the stable is timber lined, automatic sprinklers should be present.

Each stable exit should have an emergency fire door, or doors, of steel plate hung in a concrete or masonry doorway.

Open lights should never be permitted in a stable. When the mine is an open-light mine, men entering the stable should be required to leave their lamps at the entrance. A fireproof closet or space should be provided and arranged with hooks or shelves for the lamps. If incandescent lamps are not used, there should be lanterns, or preferably safety lamps, to be exchanged for the open lights carried by men entering.

Fires within the interior of coal mines are seldom accompanied by loss of life, as there are usually several ways of getting out of a district; the air currents carry the odor of the burning material to the men working on the return side, so that they are nearly always thus warned in time to escape.

In metal mines, however, the movement of air is often sluggish and many levels or cross-cuts are driven a long distance with no other provision for ventilation than the exhaust of the air drills. Under such circumstances, a fire starting in timbering at the entrance to a gangway may cut off the escape of men working at the breast.

Fires starting in the face or breast of the workings, either in coal or ore, usually do not endanger life nearly as much as do fires near the shafts or inlets, though in coal mines they may be hard to put out and are particularly dangerous if the mine is gaseous.

Fires in the interior of coal mines may be grouped, for discussion, by locality, as follows: (1) In gangways or entries; (2) at the face or "in the solid"; (3) in pillar workings; (4) in abandoned workings.

Fires in entries or headings are started generally by open lights setting fire to dry timber or brattice cloth, usually at a siding where men gather to rest. Mules or horses may be fed at such places and hay may be littered around. At a ventilating door the trapper boy sometimes digs a hole in the rib at one side of the door in which to rest while waiting for trips to pass. Engineers of the bureau have examined mines in which it has been noted that these resting places have been lined with loose hay. There have been fires that were said to have started in one or another of these ways.

To lessen the chances of such fires, safety lamps should be substituted for the open lights. English statistics indicate that there are vastly more accidents in open-light mines than in safety-lamp mines in the same districts.

Fires at the face may be caused by a blast setting fire to the coal or to small gas "feeders." Blasting is

probably the most fruitful source of mine fires in this country, and largely because of the excessive use of black powder and dynamite in many coal fields. In certain Western coal fields it is not uncommon for several fires to start in a mine every night from shooting. "Fire bugs" or "fire runners" (firemen) are employed in these mines to put out the fires. Such fires break out more often in mines that "make a little gas," than in what are termed "gaseous mines," because more precaution is taken in the latter; yet a shot overcharged with black powder or dynamite is liable to set almost any bituminous coal on fire.

Permissible explosives used under the Government regulations lessen the chance of fire. Inspection of the shots as soon as possible after firing and the placing of portable fire extinguishers in boxes at convenient points are wise precautions. A still wiser precaution is to have a complete system of water pipes throughout the mine, with taps at intervals of not over 100 feet and with portable hose and nozzle at regular intervals of about 200 yards. This system has been employed in a number of mines. Although its first cost is considerable, it affords efficient fire protection; moreover, in bituminous coal mines it is convenient for laying coal dust, thus lessening the danger of explosions.

Fires in pillar workings, that is, where pillars are being drawn, start in much the same way as those in solid workings, but pillar fires originating from explosives are less frequent because smaller charges of explosives are usually needed for pillar coal.

Fires in pillar workings are harder to put out by direct attack than those in the solid coal on account of the falling roof; if stoppings must be used, they can not be built so readily, nor made tight in the broken coal. In consequence, large areas may have to be inclosed or sealed.

Gob fires are frequent in the lignite and sub-bituminous coal of the Rocky Mountain fields, in the bituminous coal of the Iowa and Missouri field, and parts of the Illinois field, also to a less extent in other coal districts of United States. Generally their origin is due to spontaneous combustion. In coal mining the terms "spontaneous mine fire" and "gob fire" are almost synonymous. These fires may start in abandoned or caved workings of any mine, and in the process of pillar-drawing if the work proceeds slowly. Gob fires are particularly liable to occur in mines in which the coal absorbs oxygen rapidly. Such coal has a relatively low fixed carbon content and a high moisture content. It is a debated question how far the sulphur content of the coal (visible as iron pyrite) is responsible for spontaneous fires. Formerly it was believed to be the chief factor; now it is generally thought to be only an auxiliary factor. In either case it is safer to load the "sulphur balls" into cars and send them out of the mine.

Often "bug dust" (machine cuttings) left in the goave of long wall workings is particularly liable to give trouble by firing spontaneously; moreover, in open rooms dry coal dust, if stirred up by a blown-out shot, is a source of danger from its liability to ignition. Therefore all cuttings and fine coal should be sent out of the mine.

A gob fire probably originates in the following manner: The coal and the shale from the roof or partings disintegrate as the occluded gases escape; at the same time oxygen is absorbed. At first oxidation is slow. In a goave when the roof falls the heat is retained so that the temperature rises. With the rise in temperature more gas is liberated, and oxidation becomes more rapid. These reactions continue until the temperature reaches a dangerous point.

Fires often originate in the vicinity of timber. It has been suggested that timber acts as tinder; in other words, it probably ignites more easily

and more rapidly than the coal itself.

The outward manifestations of a spontaneous gob fire are, first, that beads of moisture appear on the roof and upper part of the timber props at the edge of the gob—the heat may or may not be appreciably; second, that the heat becomes perceptible and the drops of moisture disappear—thereafter the rise in temperature is very rapid. In the beginning of a gob fire the circulation of air is insufficient to carry off the heat developed in the gob, yet enough air is present to cause slow oxidation. These opposing conditions are not easily met, and gas if present causes difficult complications.

In pulling pillars or in long-wall work, it is very difficult, and in some cases impossible, to ventilate the goave sufficiently to keep it cool. On the other hand, the working places of the miners must be ventilated and some of the air current drifts into the goave, thus providing sufficient air for the oxidation.

In some coal fields the fallen shale or "slate" roof fires "spontaneously." In the Iowa field and in some parts of the Illinois field it is necessary to seal off rooms as soon as they have been finished or have been stopped by great falls; otherwise the material heats and fires quickly. It would be better if the pillars in such mines were extracted, so that there would be a complete closing down of the roof. Gob fires rarely occur in a tightly packed long-wall goave, and never where hydraulic filling or flushing is employed, as in Upper Silesia, Germany. This is one reason why this system has been used in the thick (20 to 40 foot) coal bed of that district, where formerly gob fires were of frequent occurrence and difficult to extinguish.

Where the customary room-and-pillar system is employed in mines liable to gob fires, if the pillars can not be quickly drawn, it is generally best to seal off promptly before the gob heats. A concrete or brick wall, coated with cement, should be used, a pipe with a gate valve being put through it near the top, so that temperature readings and samples of the gases may be taken. There is serious objection to sealing off rooms when the mine produces methane in any quantity, because a large body of standing gas, even behind a strong stopping, is a constant menace. In such a mine the pillar-and-stall method of mining, or some form of long-wall, should be employed.

Fires from electric incandescent lamps are liable to be caused by allowing such lights to rest in contact with wood or coal dust, or even the coal itself.

A more fruitful source of fires is the short-circuiting of improperly installed lighting or power cables. The remedy is to have all electric lights and wires installed and regularly inspected by a competent electrical engineer.

Trolley wires for an underground haulage road should be installed with great care and should be inspected often. Several serious mine fires, one of which involved the loss of a large southern Illinois mine, are said to have been caused by the short-circuiting of trolley wires, which set fire to the wooden frames of doors. To protect against such short-circuiting, doors, when necessary along the trolley road, should be set in brick or concrete frames.

Another cause of fire along entries is the grounding of power lines or trolley-road returns. Many fires have originated from this cause. In this country power lines in mines are seldom armored or even rubber covered; a fall of roof or a movement of timber may bring the bare charged wire in contact with either wood or coal. If such lines are placed in entries not often traveled, as is frequently done, a fire may become serious before it is discovered.

The remedy is regular inspection at least twice a shift while the current is on, or the armoring of such cables. In long-lived mines it may prove economical in the end to have the

power cables inclosed in conduits that lie in covered trenches.

Underground ventilating fans, especially so-called "booster" fans to help the surface fans, are being used more and more. In Europe such fans are usually driven by compressed air, a safer but more expensive method than by electricity, which is used in this country. As it is necessary in most places to drive the fans all the time day after day, it is evident that in spite of daily inspection there is liable to be a time when an armature gets overheated and the insulating material takes fire. This is supposed to have happened in a large Ohio mine, where the fire got beyond control, so that a large section of the mine had to be sealed off.

Generally such fans have been set in wood frames, or there has been timbering near at hand which could be set on fire by the burning of the insulating material.

The remedy is to set such an electrically driven fan in a non-combustible frame, to line the passageway for some yards with brick or concrete, and then to inspect the fan often.

Great explosions of fire damp and particularly of coal dust nearly always leave fires in their trail along timbered entries or where the coal dust is thick. The using up of the oxygen and the damping effect of the carbon monoxide and dioxide produced by the explosion fortunately put out most fires thus started. But if the ventilation is quickly restored in order to save life, or if there are areas not reached by the explosion and able to supply air, the fires are likely to revive. In a certain breakthrough between rooms, in an Alabama mine, the burning dust from an explosion fell on a pile of fine coal, and the fire lay dormant for several days; then, when the ventilation was restored, it burst out actively.

To fight mine fires the possession of proper appliances is necessary, of course, but even more necessary is the organization of a fire-fighting force and the systematic arrangement of the appliances.

The easiest time to put out a fire is within a few minutes of the start, when one man, with (or even without) an extinguisher, may be able to put out with ease a fire that half an hour later may progress so far that direct attack is impossible and the sealing of a section or even of the whole mine may become necessary.

Two things are of great importance in fighting mine fires:

First—A system of patrol should be established. The foreman and assistants should so divide or district the mine that every district is readily patrolled or examined. The same patrol is needed for other work, such as inspection of the roof and timbering and supervision of the working force. Often no additional men would be required for this work, but simply a careful division into districts, as in the "deputy system" of Yorkshire, England. Even when additional men are required by this system the saving, besides the greater security, justifies its adoption.

Second — Fire-fighting brigades should be formed. It is not to be expected where, as at the average mine, there are a large number of employees who do not speak English, that the whole mining force could be interested in the movement at first, but in all mines there are foremen and assistants who speak English. They, from the nature of their position, can generally be relied upon to carry out the purposes of the management, and could form the foundation of the organization. In general, the chief foremen would have corresponding positions in a fire-fighting organization. The regular pumpmen, assisted by the machinists, should have the duty of handling the fire pumps, if there are any.

Each district should have for its local chief a man who, in the course of his regular duties, would always be within this district. He should have appointed to answer fire calls promptly a number of men who

would leave their regular work only on emergency calls. To each of these men would be assigned a special duty, such as getting hose, turning on water, getting portable extinguishers or breathing apparatus, notifying the miners in the district to get out by certain roads, or to open or shut emergency doors.

It is probable that there will be not enough assistants or even "company men" (paid by the day) who speak English; but undoubtedly the ranks can be filled with miners interested by reward or appeal to their ambitions.

Fire drills should be undertaken at regular intervals in each district, say twice a week. A convenient time is during the lunch period, when haulage is stopped, the squad eating lunch before or after a drill. These drills should be for different assumed locations of fire. Similar fire-fighting squads should be organized for surface fires. Competitive monthly drills, in connection with which rewards are given, will sustain interest in the work and exercise the inventive faculty of the men along fire-fighting lines.

When the mine is near a town, a plan to co-operate with the town fire department is advisable. Such co-operation has been adopted in a number of the mining towns of Germany, and in Newcastle, England, with a large shipbuilding plant.

Important help would be given to fire-protection organization by providing each fire division with special fire-fighting maps, a general map of the mine, and separate maps of each fire division. These maps should not be too large for easy inspection, each one being not over 2 by 3 feet.

The general fire-fighting map should be only a skeleton map of the mine showing the shafts and entries, and levels or headings, with the pipe lines and taps or hydrants, pumps, sumps, fire signals, and the ventilating system including overcasts and doors, as in fighting some fires a change in the direction of flow of the ventilating current might become necessary.

The division maps should show the details of the mine workings within each division, and in addition all details of fire-fighting apparatus. These division maps may be sun prints on cloth—black lines on a white background—printed from the regular mine-map tracing. After the prints of each division have been made, the position of fire apparatus should be shown on the maps with waterproof red ink. Each foreman in charge of a squad should be supplied with a set of maps which should be kept at the division headquarters of his district.

The management should accustom the fire-fighting corps to the use of these maps by marking on them for fire drills the position of assumed fires.

Equipment useful in fighting fires may be divided into seven groups:

1. Breathing apparatus and portable electric lamps.
2. Telephone and alarm apparatus.
3. Portable extinguishers and buckets.
4. Water lines and hose.
5. Fire pumps.
6. Emergency fire doors and stoppings.
7. Ventilating fans.

Breathing apparatus, portable electric lamps, and several safety lamps for testing should be kept in each refuge chamber or division headquarters, both for fighting fire and for self-rescue in a disaster. At least two sets of oxygen breathing apparatus of two hours' capacity and half a dozen sets of the self-rescue type good for one-half to one hour should be provided for each division station. These should be examined often and kept in good condition. Extra charged oxygen tanks and extra parts should be on hand.

Portable electric lamps, either of the dry-cell or, if there is a current at hand for charging, of the storage type, are invalubale for fighting fire and are necessary for use where breathing apparatus must be worn

on account of the presence of gases in which the safety lamps might not burn or would not be safe to use.

A telephone system below ground, with connections to the surface, is an economy in ordinary mine administration, keeps the management promptly informed of mine conditions, and is of vital importance. Too often the wiring is put in hastily and improperly, although it should be put in with even more care than a surface system. The wire should, if possible, be taken down a drill hole at some distance from the shafts so that the line will be in less danger of being cut off by fire or explosion. On account of these dangers it is best to have two or more lines pass into the mine through different openings.

Several makes of good mine telephones inclosed in iron boxes are now on the market. They are practically damp proof, and such instruments have passed without injury through the severe ordeal of a mine explosion. There should be at least one telephone in each fire district, preferably placed at the point where the district fire-fighting apparatus is kept.

For the surface buildings, automatic fusible-plug alarms are good; whether they are adapted to use underground is perhaps a question, for the danger of their getting out of order is great.

Electric-bell fire alarms, operated from one or more points, have been proposed to warn mine workers, so that if an alarm is given they may run to the exits. The bells should be placed near enough to the working places to be readily heard. This system was tried in Illinois as an outcome of the Cherry disaster. It proved liable to get out of order, and its use was discontinued. Future improvements may make the use of gongs successful, but the telephone will still be a necessity.

Whistle alarms, operated by compressed air, have been suggested and might be less liable to get out of order than electrically operated gongs.

An excellent fire-alarm system in one of the large copper mines is as follows: If fire is discovered the hoisting signal system is used. Nine bells are rung from the level where the fire has started. These bells notify the hoisting engineer that a fire is in a certain level. The switch board controlling the lighting system is in the hoisting engine room, and the engineer immediately pulls the light switch nine times, and thus flashes the fire signal to all the parts of the mine that are lighted by electricity. This notifies many men at one time, who in turn notify miners in the stopes. Such an electric-light fire signal has the advantage of being always in repair, is not as likely to cause a panic as a bell, and, since it utilizes the lighting system, does not involve any additional expense.

Extinguishers that throw a stream of water and carbonic acid gas by pressure developed chemically are so well known and have been so successfully used for years that detailed descriptions are not needed. There should be at least three at each district station, preferably more. Such apparatus is better than anything else for quick use, and if a fire has just started a man can grab the extinguisher, run to the fire, and throw the stream on at once. Other kinds of portable apparatus that use dry chemicals sometimes do the work, but they have not been so thoroughly tried out in mines.

Chemicals that have a cooling and extinguishing effect on fires have long been sought. There are many places where water can not be obtained or applied, as in steep, pitching workings. In large areas that have been inclosed or when the entire mine is sealed off, often water can not be used to reach the fire effectively at the high or distant points.

The application of chemicals to fire fighting is a difficult problem, which the chemists and engineers of the bureau and others are constantly

studying. The use of dry-powdered chemicals in fighting mine fires has not yet been satisfactorily developed. The employment of carbonic acid gas and water jets from portable apparatus has already been referred to and commended. In the Pennsylvania anthracite field much use has been made of larger apparatus of the same type mounted on mine trucks. This apparatus has a tank of water in which the pressure is obtained from carbonic acid gas generated by the action of sodium bicarbonate and sulphuric acid placed within the tank and brought in contact with each other by the operation of a simple mechanism.

Another type of tank car is employed at the Beuthen Station, Upper Silesia, Germany, in which carbonic acid gas under a compression of 2,000 pounds per square inch is carried in a cylindrical tank on the same truck as the water tank. In the United States there are mine fire engines designed to use the pressure of compressed air instead of carbonic acid gas. The latter has the merit of being an extinguisher in itself, but even in appartus using it the water is the important thing for putting out the fire.

Fire buckets are of great value. If there is a sump or water hole in the district, and there is no water-pipe system, or if the system is out of repair, buckets may "save the day." In the experience of the bureau's engineers, fires have been encountered after some great explosions and have been put out by water-bucket brigades. Galvanized buckets appear to be the best, and a dozen of these should be kept at each division station. In the absence of water lines or standing water, barrels of water should be kept at the station.

A pipe-line system with taps, hose, and nozzles, if extended into all the working places, as in some mines in the United States, is an admirable system. Sometimes the supply to such lines is shut off from one cause or another; this is a dangerous practice, because the water may not be on in some emergency. There should be frequent tests to insure good working order. The pipes should have taps not over 100 feet apart, and 1½-inch hose with nozzles should be placed at points about 200 yards apart.

The water lines should be supplied by gravity from a tank in order to be ready for quick use, but there must be also underground fire pumps if the ordinary drainage pumps are not available. Such pumps must be readily accessible and located between the intake and return airways, so that a split of fresh air can always be carried past the pump, whether the ventilation is reversed or not.

A controllable ventilating system is of the greatest importance in fighting mine fires by active means. This is true not only in coal mines, but also in metal mines. All coal mines require a ventilating system to carry away dangerous gases, the minimum requirement in the various State laws ranging from 100 cubic feet of air per underground employee per minute to 200 cubic feet in the gaseous anthracite mines of Pennsylvania; 100 cubic feet is the prevailing minimum in the bituminous districts of the country. Usually these quantities are much exceeded.

Although all coal mines must have a ventilating system and practically all use fans, in comparatively few mines are the installations made with reference to fighting fires. Not only should the fan be built wholly of metal, but the casings also should be iron or steel or, better yet, concrete or brick; also the fan conduit to the shaft or to the entrance should be of fireproof construction.

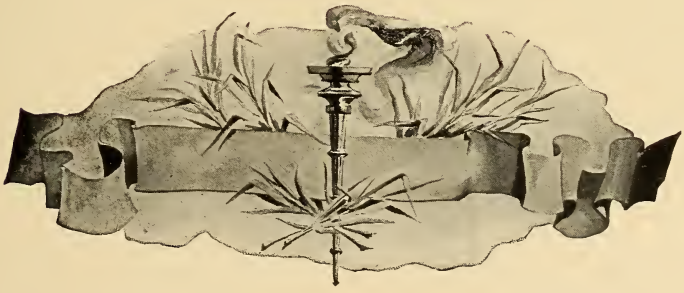
Furthermore, for fire fighting the fan should be reversible, or there should be duplicate fans, one a blowing or pressure fan, the other a suction or exhaust fan. It is also best that the air shaft be thoroughly fireproofed. If the air shaft is used as

an escapeway, the escape compartment should be separated by a thick fireproof partition. It is better to have the escapeway in a separate or third shaft.

The value of having a reversible fan is unquestionable. If a mine fire starts near the downcast shaft, a quick reversal will prevent blowing the gases around the mine and thus will probably save the miners. In one instance a fire started in the intake close to the air shaft; through the opening of doors the flame was short-circuited to the hoisting shaft, setting fire to the timbering near that shaft and making its use impossible before most of the men were out. In such a fire if the fan were reversed within the first 10 or 15 minutes the air shaft might be burned, but all the miners and the main hoisting shaft would probably be saved. It is not easy to determine in the face of an emergency what is best to be done, but facilities for effective action should be available.

Where there is a reversible fan, whenever a fire starts near the downcast shaft, whether this is a hoisting or an air shaft, if there are escape facilities at both shafts—which there always should be—by reversing the fan promptly the safety of the men underground is assured, although one shaft may be sacrificed.

(To be concluded.)



ROAD BUILDING MATERIALS

UNITED STATES DEPARTMENT OF AGRICULTURE

IN view of the increasing attention which is being given to the subject of road building, the bulletin recently issued by the Office of Public Roads of the United States Department of Agriculture is of much interest, since it deals with the properties of various kinds of rock suitable for making roads in the light of physical tests made in the laboratory of the Department. This report, prepared under the direction of Mr. Logan Waller Page, by Messrs. Albert T. Goldbeck and Frank H. Jackson, contains not only an account of the methods and apparatus employed in the tests, but also tabulates the results at length, thus enabling definite figures to be obtained for the materials investigated. For these tabulated results, as well as for the illustrated description of the apparatus, reference must be had to the original bulletin; but some general discussion of the kinds and properties of rocks for road building will be found useful.

The apparatus for testing the various properties of road material is devised so as to operate, as far as practicable, under conditions similar to those obtaining in actual service.

Thus the hardness test is made in the Dorry apparatus, as used by the French Department of Bridges and Roads, and depends for its action upon the measurement of the loss in weight of a specimen when subjected to abrasion in contact with quartz sand. The toughness test is made by an impact machine, devised by Mr. Logan Waller Page, the specimens having been cut from the rock by a core drill and sawn by a diamond saw. The cementing power is determined by grinding the material to powder, moulding the powder into briquettes, and testing these by impact. Specific gravity and absorption are measured by the well-known methods, the results of all these tests being stated according to a system of notation described in the report.

The first systematic attempt to determine the relative value of rock for road-building purposes by means of laboratory tests seems to have been made in France, when, in 1878, a road material laboratory was founded in the School of Bridges and Roads. It was here that was adopted the Deval abrasion test for rock, now, with slight modifications, standard throughout the United States. This test is named from its inventor, and was first used in connection with contract work in the city of Paris. Many valuable data were also collected in this laboratory on the hardness and toughness of rock, and tests for these qualities were developed which are the same in principle as those in use to-day.

In December, 1900, the United States Government, because of the growing importance of the problem of testing road materials, established a laboratory in the Bureau of Chemistry of the Department of Agriculture, under the direction of Mr. Page. This laboratory was transferred in 1905 to the Office of Public Roads, where its present organization was developed.

The present general interest in the necessity for good road construction has resulted, quite recently, in the establishment of laboratories in many technical institutions, both in this country and abroad, as well as in

the various State highway commissions.

The fact that a large number of samples are submitted for investigation and reported on annually by these laboratories is good evidence of the value of the information received by the road engineer through the agency of laboratory tests on the relative worth of the materials which he proposes to use in road construction, and it is the object of this bulletin to describe these tests as now practiced and to interpret their results.

The surface of a road is subject to deterioration, due to the effects of (*a*) mechanical, (*b*) chemical, and (*c*) physical agencies whose disintegrating action may be more or less combated by proper construction and maintenance with carefully selected materials. The individual stones in a macadam road are bound together by finer particles and rock powder, and the ideal condition is that in which there is always just enough dust existing to cement these stones together tightly.

(*a*) *Mechanical Agencies.* — The action of traffic on a road surface is purely mechanical. The severe impact of horses' feet tends to disturb the individual stones by loosening the binding material. At the same time, the stones are subjected to an abrasive action which grinds away their surfaces. The fine material thus created is partly carried away by the wind and partly washed away by the rain, while part is retained on the road under favourable conditions to form new cementing or binding material. Should there be more fine material formed by abrasion than is carried away by the wind and rain, the road becomes dusty and muddy; whereas if too little fine material is formed to cement the particles of rock together, the road disintegrates because of raveling.

Automobile traffic exerts a severe shearing action on the road surface which loosens the individual stones, but fails to supply, by abrasion, enough additional fine material to compensate for that lost in the clouds of dust raised by this class of traffic. As a consequence, plain macadam construction ravels when subjected to considerable fast-moving automobile traffic.

(*b*) *Chemical Agencies.*—Since all rain and surface water contains carbonic acid in amount sufficient to dissolve carbonates of lime and iron, there is some disintegration from this source. The humus acid derived from animal and vegetable decay likewise renders soluble certain of the rock-forming materials containing magnesia, potash, soda, lime, iron and silica. However, investigations have shown the deterioration of road surfaces from this source to be negligible.

(*c*) *Physical Agencies.*—Although it is probable that rock used in road making is very little affected by the action of frost, the action of repeated freezing and thawing on the body of the road is considerable. This is particularly true in the event of poor drainage, because the absorptive power of the roadbed is, in general, quite high, even though the absorption of the rocks used is low. The materials loosened up by the heaving action of the frost are carried away, to the detriment of the road, by the mechanical action of wind and rain.

The action of mechanical agents is by far more severe in causing the destruction of a road than either chemical or physical agents, and the ability of a rock to withstand mechanical destruction is of great influence in judging its value as a road-making material.

A road-building rock must have three very essential characteristics—i. e., it must be (*a*) hard and (*b*) tough, and (*c*) it must have good cementing or binding power.

(*a*) By the hardness of a road material is meant its ability to resist the abrasive action of traffic in causing displacement of the surface particles by friction.

(*b*) The toughness of a rock is a

measure of its ability to resist rupture due to the impact of traffic.

(*c*) The cementing or binding power of a rock determines how firmly the individual stones will be cemented together by the rock powder formed through the action of traffic.

To determine the above three characteristics essential for a good road material, as well as to investigate other minor physical features, the following tests are made: (1) Hardness; (2) toughness; (3) resistance to wear; (4) cementing value; (5) specific gravity; and (6) absorption.

The binding power or cementing value of a road material is the property possessed by rock dust or other finely divided material to act as a cement on the coarser fragments composing crushed stone or gravel roads. "This property varies enormously, not only with different kinds of rocks, but also with those which are practically identical in classification and chemical composition. The absence of cementing power is so pronounced in some varieties of rock that they can never be made to compact with the road roller or under traffic. As the binder surface of a macadam or gravel road is most exposed to the action of wind and rain as well as the wear and tear of traffic, it can be seen that the presence of this property is most essential to good results. Further than this, the hardness and toughness of the binder surface, more than of the rock itself, constitute the hardness and toughness of the road; for if a load be sufficient to destroy the bond of cementation of the upper surface of the road, the stones below are soon loosened and forced out of place. The impervious shell obtained by the use of a rock of high cementing value gives the greatest protection to the foundation of a road. Moreover, it is a matter of common observation that a good surface which binds well is less dusty and less muddy, while the advantage from the standpoint of economy is very great, as it is only the loose, unbound material which is ordinarily carried away by wind and water."

Investigations in the United States Bureau of Chemistry indicate that the cementing value depends on certain hydrated colloid conditions of the particles. All rock powders that cement well are hydrated—that is, they contain water of combination, although it does not follow that all hydrated rock powders will cement. It seems that only a certain kind of water of combination is concerned with and measures the cementing value. This property is undoubtedly related to that of plasticity in clays and, in a few words, is due to the amorphous inorganic particles, which, by reason of their characteristic porous structure, are able to absorb and hold water, thereupon assuming a plastic and coherent condition."

1. *Hardness.*—Rocks having a coefficient of hardness below 14 are called soft; from 14 to 17, medium; and above 17, hard.

2. *Toughness.*—The results of the toughness test are interpreted so that rocks which run below 13 are called low; from 13 to 19, medium; and above 19, high.

3. *Resistance to Wear.*—In interpreting the results of this test, a French coefficient of wear below 8 is called low; from 8 to 13, medium; from 14 to 20, high; and above 20, very high.

4. *Cementing Value.* — Cementing values below 10 are called low; from 10 to 25, fair; from 26 to 75, good; from 76 to 100, very good; and above 100, excellent.

5. *Absorption.*—The absorption test is of value in judging the probable lasting qualities of the rock under the action of frost. The presence of frost in the stones is likely to be productive of weakness or disintegration, and, for this reason, is liable to cause rapid crumbling of the screenings and the wearing surface of the road. The higher the absorption, the greater the effect of frost. In bituminous-bound work some observations seem to indicate that it is

of advantage to use a rock of high absorption rather than one with low absorptive qualities, since the bituminous material is taken in by the porous rock and binds it together more efficiently than in the case of rocks of low absorption. The indications are that the cushioning effect of the bituminous binder renders the rock in a bituminous-bound road more resistant to wear than in a water-bound macadam, making it possible to use a softer rock than in water-bound construction when subjected to the same traffic conditions.

It is manifestly impossible, because of the varying conditions of traffic and climate to which roads are subjected, to give rock samples a numerical grading of excellence from the results of laboratory investigation. Nevertheless, a very accurate preliminary idea of their value for the purpose in hand may be obtained from a consideration of the laboratory results taken in conjunction with the probable traffic and climatic condition.

The ideal rock for the construction of a macadam road is one which resists the wear of the traffic to which it is subjected to such an extent as to supply just a sufficient amount of binding material to cement the road. If, after the road is constructed, the traffic is not sufficiently severe to wear off the requisite amount of binder to replace that carried away by wind and rain, the road "ravels." Should an excess amount of fine material be worn away, the road becomes muddy and dusty. In either case the rock was not suited for the road on which it was used. A softer rock should have been used in the first case and a harder, tougher rock in the last case.

In the case of a very lightly-traveled road or parkway, the best results could be obtained, not with a hard, tough rock, but with a softer material with a good cementing value. Under the conditions to which this type of road is ordinarily subjected, a hard, tough rock would build a road likely to ravel, because of the lack of binding material supplied by traffic, whereas if a softer material were used, sufficient binder would result from the wear produced by traffic.

For the construction of heavily-traveled roads, a very hard, tough rock with good cementing value is necessary.

The following facts should be taken into consideration before attempting to interpret the results of the laboratory tests on samples of rock intended for use in macadam-road construction, viz.: 1. The character of its traffic to which the material is liable to be subjected, whether (*a*) automobile, or (*b*) horse-drawn—and if so, whether (1) heavy, (2) medium, or (3) light. 2. The character of the material under examination—that is, (*a*) its name, and (*b*) its approximate mineral composition and structure. 3. The behaviour of material of a similar nature in actual service. A knowledge of these three points is essential to an intelligent interpretation of the laboratory tests in any specific instance.

1. *Character of Traffic.*—The following discussion will apply only to materials which are to be subjected principally to horse-drawn traffic, as ordinary macadam roads have been found impracticable when much automobile traffic exists. Assuming the traffic to be principally horse-drawn, it is necessary to know whether it will be heavy, as in the vicinity of the large cities; medium, as on the principal country highways; or light, as on park or the less important country roads. It has been found by experience that certain rocks, such as the hard, tough traps, are no more suitable for use on park roads than are the softer limestones for the main arteries of a large city.

2. *Character of Material.*—It is of value to know the name and character of the material under discussion in order that an intelligent com-

parison may be made with similar materials in actual service.

3. *Behaviour of Similar Rock in Service.*—No matter how carefully conducted, it is impossible for laboratory tests to do more than approximate the conditions of actual traffic. It would, therefore, be impossible to judge accurately the qualities of a road material from laboratory tests alone, unless supplemented by the experience obtained by observation of similar material in service.

The various rock types commonly used in road construction will be considered in order; the relation between the laboratory tests and the results obtained in practice as determined by observation will be shown, and the particular class of traffic to which the rock is best adapted will be indicated.

TRAP

The traps, including the usual varieties of diabase, basalt, andesite, gabbro, etc., on account of their high resistance to wear, hardness and toughness, are particularly well adapted for roads subjected to heavy teaming. They also bind well on the road, provided the traffic is heavy enough to supply by wear enough fine material to replace that lost by natural causes. The low cementing value sometimes found is apparently not borne out in practice, since these rocks bind well on the road. Otherwise, the laboratory tests appear to agree quite closely with the results in practice, and Table No. 2 may, therefore, be applied quite rigidly to this class of material.

LIMESTONE AND DOLOMITE

Low resistance to wear and a good binding value, which are the distinguishing characteristics of the limestones, are usually shown quite plainly from the results of laboratory tests. The results of laboratory tests may, therefore, be taken as a very fair indication of the probable behaviour of the material in service.

GRANITES

Lack of toughness and binding power renders the granites, as a class, unfit for use in any but the foundation courses of macadam roads. The laboratory test will usually show these defects, except in the case of highly altered material, which will invariably show a good cementing value in the laboratory. Experience has shown, however, that even such material should not be used for surfacing, on account of the ease with which it disintegrates under traffic.

SANDSTONES

The laboratory tests do not agree concerning sandstones as closely as they should with the results in practice. This is especially true in their wearing and binding qualities; for, although these tests quite frequently run high in the laboratory, it is undoubtedly true that, except in some instances, material of this nature is unsuitable for use except in the foundation courses. As a rule, therefore, it is necessary, in judging this material, only to determine whether it has sufficient strength to stand up under the roller.

CHERT

Chert is a very hard material, and usually shows good resistance to wear and rather low cementing value in the laboratory. It has been found, however, that it, in general, develops good binding qualities on the road.

GNEISS, SCHIST AND SLATE

Owing to their foliated structure, gneiss, schist or slate should never be used in road construction when a better material is available.

MARBLE AND QUARTZITE

Neither marble nor quartzite is of much value to the road builder for the wearing courses of macadam roads, the first on account of the crystalline structure and the second on account of its extreme hardness and lack of binding power.

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Established 1891

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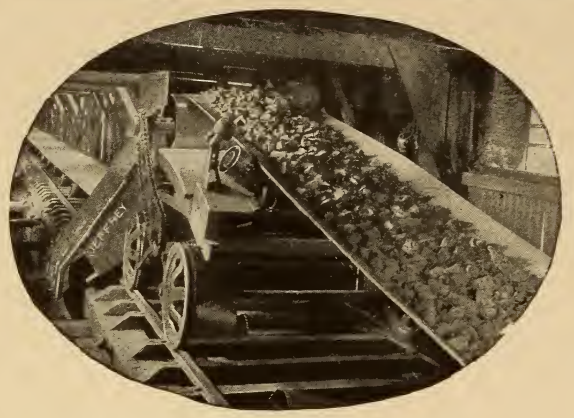

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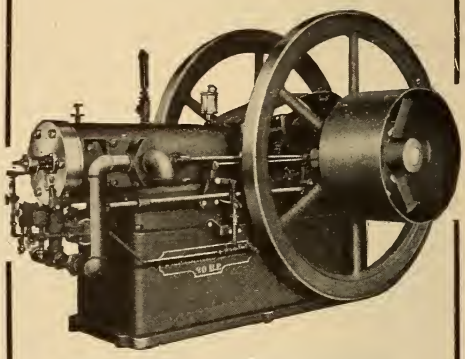

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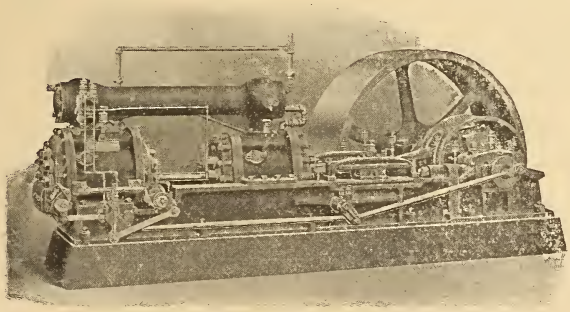

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Evidently Dr. Worcester's definition is correct and the cause for the effect, yes, effectiveness of advertising in Cassier's Magazine is clearly shown.

Francis W. Hoadley

Secretary, The Cassier's Magazine Co.

Edward A. Rumely, whose portrait we publish in this issue, was born at La Porte, Ind., in 1882, being the son of Joseph J. Rumely, and grandson of Meinrad Rumely, the founder of the agricultural machinery manufacturing industry of the M. Rumely Company, of La Porte.

He received his early education in the schools of his native State and, after studying at the University of Notre Dame, he went to Germany, attending the University of Heidelberg and the University of Freiberg, from which latter institution he received the degree of Doctor of Medicine. Upon his return to America he carried out his original ideas in connection with education, by founding the Interlaken School, near La Porte, of which institution he is still president, but has devoted his energies largely to the extensive development of the M. Rumely Company, especially in connection with the production of powerful tractors, using internal-combustion engines, with kerosene fuel, for the replacement of animal power in agricultural work.

Dr. Rumely is particularly effective in the whole subject of the development of agricultural efficiency, both by proper educational methods and by the application of power machinery; and by his work and his writings he has done much to advance the cause of efficiency in these departments of work. He is a member and director of the State Commission of the National Association for the Promotion of Industrial Training, and a member of the American Association of Agricultural Engineers, and is secretary and treasurer of the M. Rumely Company, of La Porte, Ind.

Photograph by Gertrude Kasebier

DR. EDWARD A. RUMELY

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CASSIER'S MAGAZINE

AN ENGINEERING MONTHLY

VOL. XLII NOVEMBER, 1912 No. 5

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MODERN GRAIN STORAGE CENTERS

By William A. Day

TO the one who knows little about the "moving" of the American grain crop, the term elevator is apt to be confounded with the mechanical system by which people and freight are carried up and down in hotels, office buildings, theaters, and other structures where the height from the ground necessitates the "lift," as it is more appropriately termed abroad. To-day the elevating section of a grain storage plant or depot stands for but a single feature of its construction, and is merely the method by which the wagon, railway car or vessel is unloaded and the grain raised and distributed into the various compartments.

Considering the weight of even 100,000 bushels of wheat or corn, the problem of providing a building which will hold merely this quantity is an interesting problem from the engineering standpoint. The engineer or expert contractor must reckon with the lateral pressure, also the downward pressure, and carefully calculate the strength of the exterior walls as well as flooring. Where the capacity is for a million or more bushels, here is a weight of 30,000 tons for the minimum capacity.

Such is the reason for the planning and erection of such storage houses in this country that are models in their design, mechanical equipment and construction. With the increase in production of iron and steel, new materials are available for such work. Concrete is another valuable, often necessary, element. Thus it is that the frame elevators are rapidly being replaced by stronger and more durable buildings. While the massive stone grain "depots" seen on the harbors of Liverpool, Antwerp and, even as illustrated in a previous issue of CASSIER'S, at Constanza on the Black Sea, indicate the ability of the European designer, the large elevators at ports on the Great Lakes, railway terminals as well as on the lower St. Lawrence River and the Pacific Coast, have a greater capacity than those of Europe. while the plans by which they are built represent the ideas of the leading American engineers.

The modern grain holders in this country include widely differing designs. The development of conveying mechanism, and the employment of electricity for motive power, have admitted of several new designs of construction. A striking illustration of the dimensions of the new type of storage house may be briefly described: Its steel framework rests upon 280 columns of the same material, in turn supported upon concrete pedestals and piling. The outside

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ELEVATOR AT LUDINGTON, MICH., FOR UNLOADING BOATS AND CARS

walls of the lower portion consist of brick resting on stone foundation. The storage compartments are steel bins, each 85 feet in height, and varying from 6,300 bushels to 24,900 bushels capacity. The bins are made of plates 5 feet in length and ranging from 5/16 to 3/16 of an inch in thickness.

The arrangement of the floors is similar to that in the ordinary elevator, but in operation the cars are hauled into the building in trains of nine each by a cable system. As the grain passes from the cars into the hoppers, it is taken by endless-belt carriers from the hoppers to the top of the elevator, where it falls into the garners, thence into the scale hoppers, and then to the scales. From these it drops through a swinging turnhead into spouts, from which it is taken by a belt conveyor and handled longitudinally of the building and delivered into the proper bin. If it is to be cleaned it falls through the bin to one of the cleaning legs, which elevates it. Then it passes over the sieves of the cleaning machines, returns again to the top of the house, and down into a bin. Before being sent to the shipping bins the grain is weighed a second time.

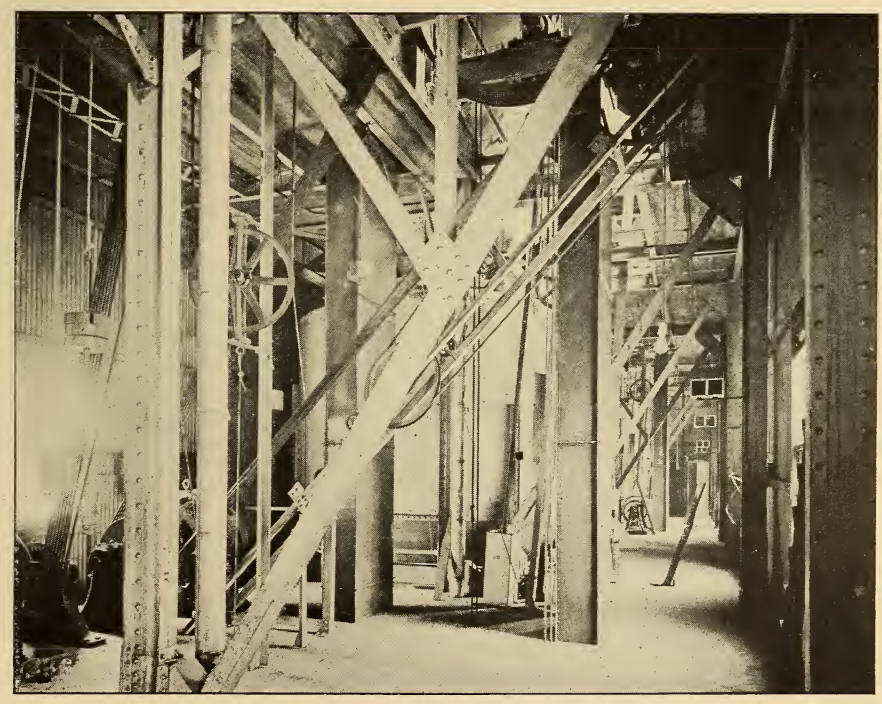
A novel feature of the equipment is a system of automatic shovels, there being one for each car. Each set of nine shovels is so placed on a hanging track that a shovel can be mechanically placed in any one of the cars. In providing power for the various processes, the plan was followed of utilizing electric motors as much as possible. Electricity is depended upon entirely, even the cable system for hauling cars into the building being operated by a 100 horse-power motor. Each conveying belt, cleaner leg, fan and power shovel is operated by an individual motor ranging from 7½ to 100 horse-power, requiring a total of 2,070 horse-power. The elevator loads 300,000 bushels of grain in twenty-four hours on board vessels, and unloads 600 cars during the same period.

This elevator was built for storing grain at one of the terminals of the Great Northern Railway on Lake Superior. This system, passing through the wheat belt of Minnesota, the Dakotas, with branches in Manitoba, has a very large grain traffic to the East-

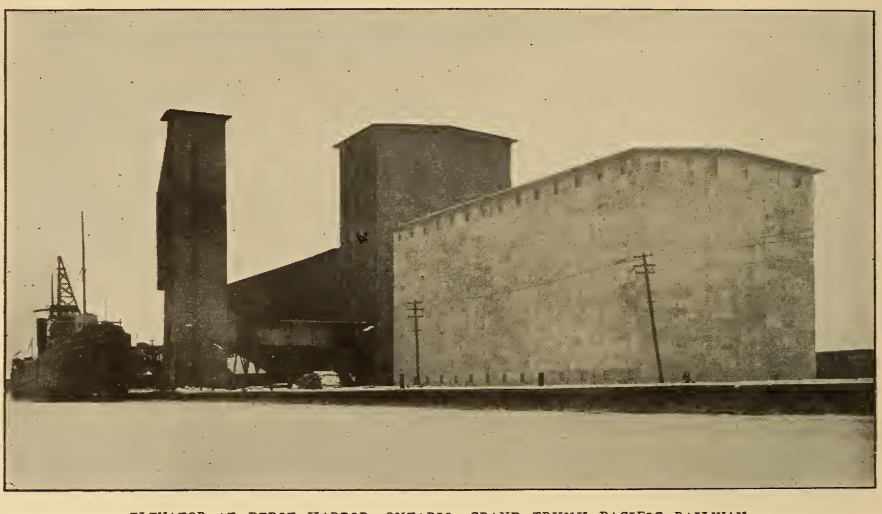
ern market by way of the Great Lakes, and the West Superior plant was built with the idea of storing the grain and so located that its contents can be loaded in the lake carriers by gravity, the vessels taking on a cargo as large as 10,000 tons in an hour.

The small elevators constructed at railway stations in the grain belt of the Western States may be seen nearly every hour in traveling in this West. They are as much of a necessity as water tanks. When the wheat harvest begins to move, the wagons heaped up with their loads are driven to the nearest elevator. Here the loads are pulled up to the center of an inclined plane, where the wheat falls through a spring door into a receptacle to be cleaned by an air current that removes all of the dust and foreign particles. It passes to the real elevator, which comprises an endless rubber belt running over two pulleys, one in the boot at the bottom and the other in the head. Upon the belt are fastened at regular intervals metal cups facing in the direction in which the belt travels. As the pulleys revolve, the cups scoop up the grain from the boot, carry it to the head, and as the cups are inverted in passing over the strap pulley, empty it into a spout placed there to receive it. The legs of these small elevators can lift a thousand bushels an hour. The grain now goes into storage for a day, a week or a month, until ready to be shipped to market, when the grain cars are hauled to the side of the mill and filled by gravity through troughs or metal pipes. Some of the small mills have electric motors for actuating the cleaning fan and belt conveyor, but in most of them are installed a steam engine of from 5 to 10 horse-power.

The advantages of these local storing centers are that they are in the Grain Belt and so distributed that they can readily be reached from the harvest field, thus avoiding the time and needless labor of unloading at the farmer's barn and then reloading when he sells his output. The elevators are also weather proof and



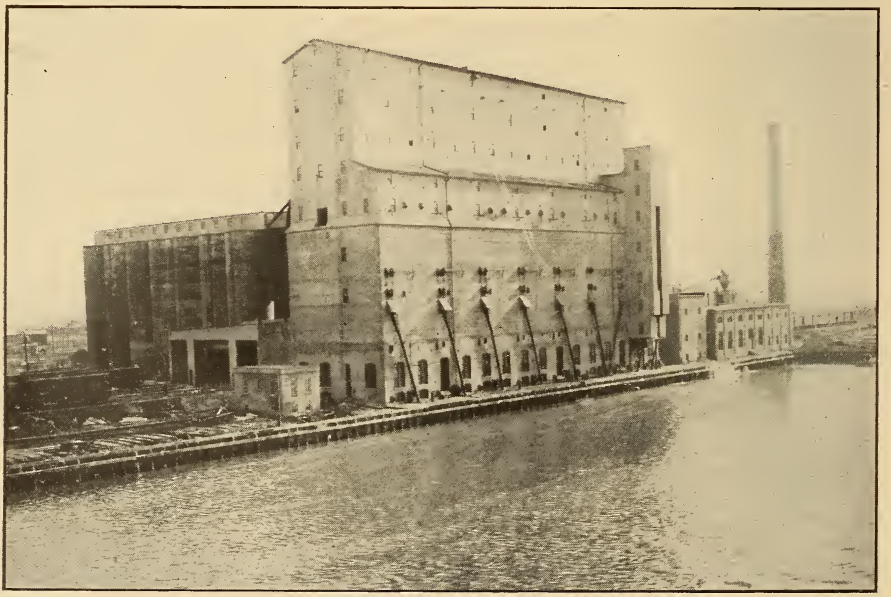
SHIPPING SCALES, MOTORS, ROPE DRIVE AND ELEVATOR LEGS



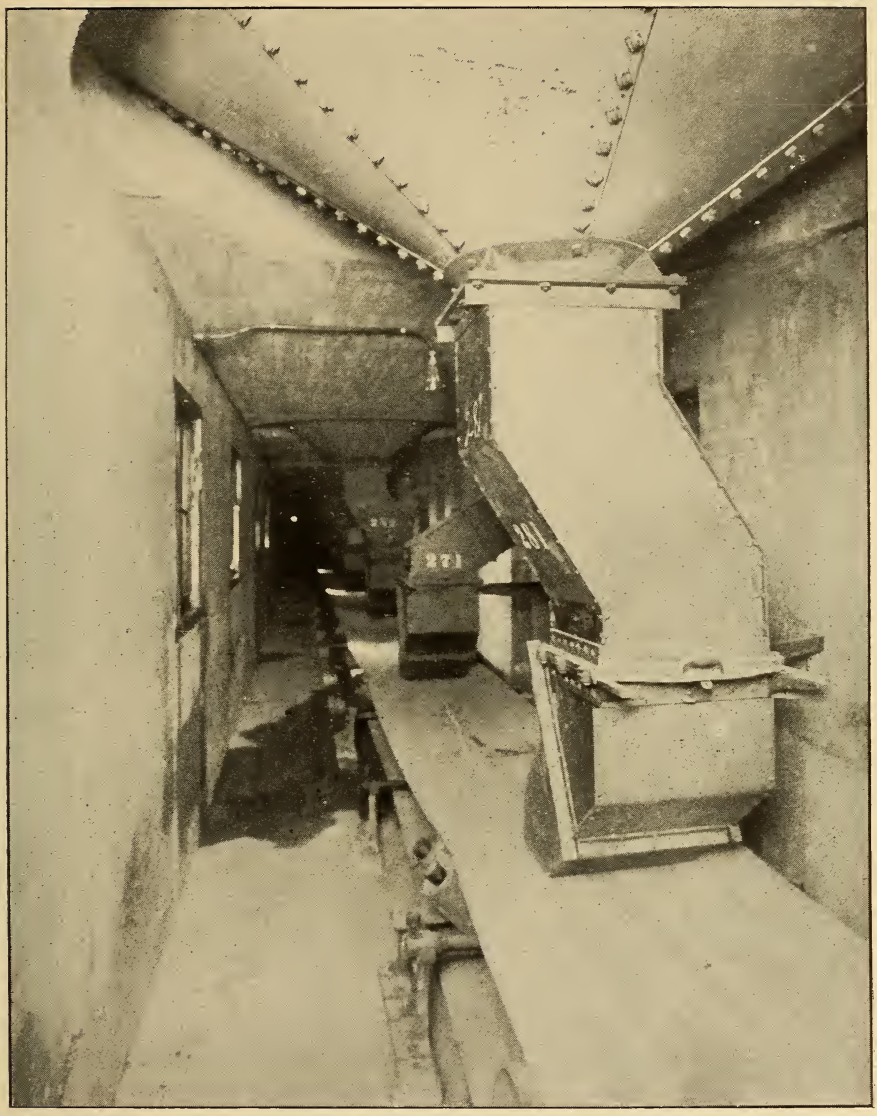
ELEVATOR AT DEPOT HARBOR, ONTARIO, GRAND TRUNK PACIFIC RAILWAY

keep the wheat or corn dry and in better conditions than if held on the farms. Their capacity ranges from 2,000 bushels to a maximum of about 10,000 bushels. As an economic factor in agriculture they are of great importance in this way: If the market price decreases on account of a larger crop in the Argentine Republic or some other competitive region, the grain can be stored a year or more until prices are satisfactory. Thus through the elevator system the wheat growers are not forced to sell at a loss to make room in their farms and storehouses for other necessities.

The large inland elevators are built principally by the grain-carrying railway companies to receive the output obtained from the local centers of grain collection. The sites chosen are usually railway junctions or railway



SANTA FE ELEVATOR, CHICAGO, SHOWING MARINE TOWER AND LOADING SPOUTS



BELT CONVEYOR AND BELT LOADERS FROM STORAGE BINS, SANTA FE ELEVATOR, CHICAGO

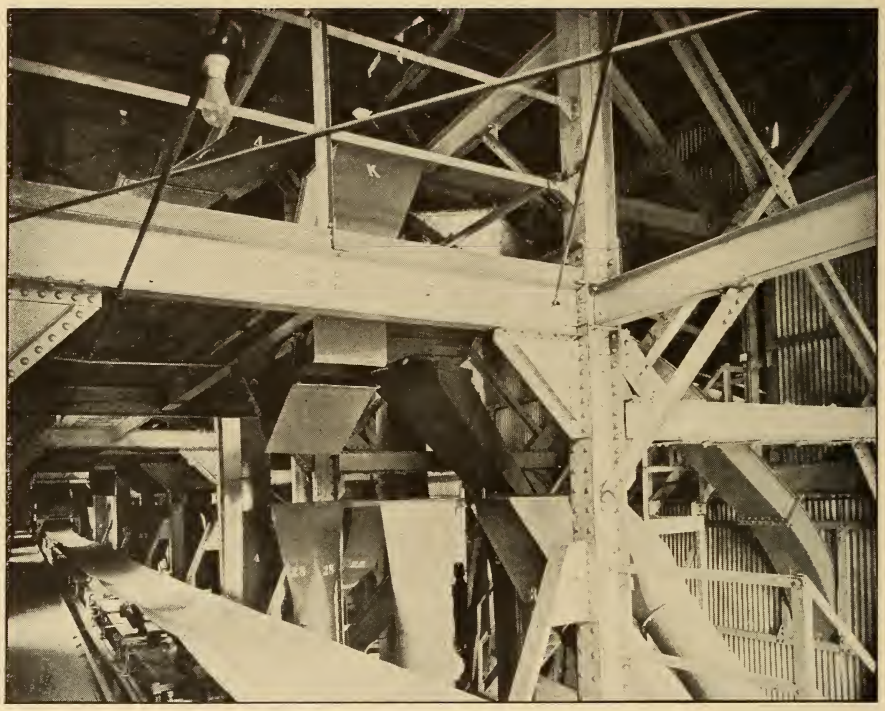
terminals where the most direct route to the domestic market or to the loading wharf for export can be reached. It may be needless to say that Chicago and Buffalo on the Great Lakes are important elevator centers, as well as the little Canadian lake port of Tiffin, which is the site of one of the largest American storage houses, holding a maximum quantity of 2,000,000 bushels. Kansas City and St. Louis are important inland receiving and shipping points, since each is reached by rail systems traversing the great fields of Missouri and the northern prairie States, while they also have lines extending to the Gulf and Atlantic seaboard.

We have already referred to the construction of the steel tank elevator built for the wheat traffic of the Great Northern Railway Company. The receiving plant at Tiffin, Ontario, is of much interest, since the material com-

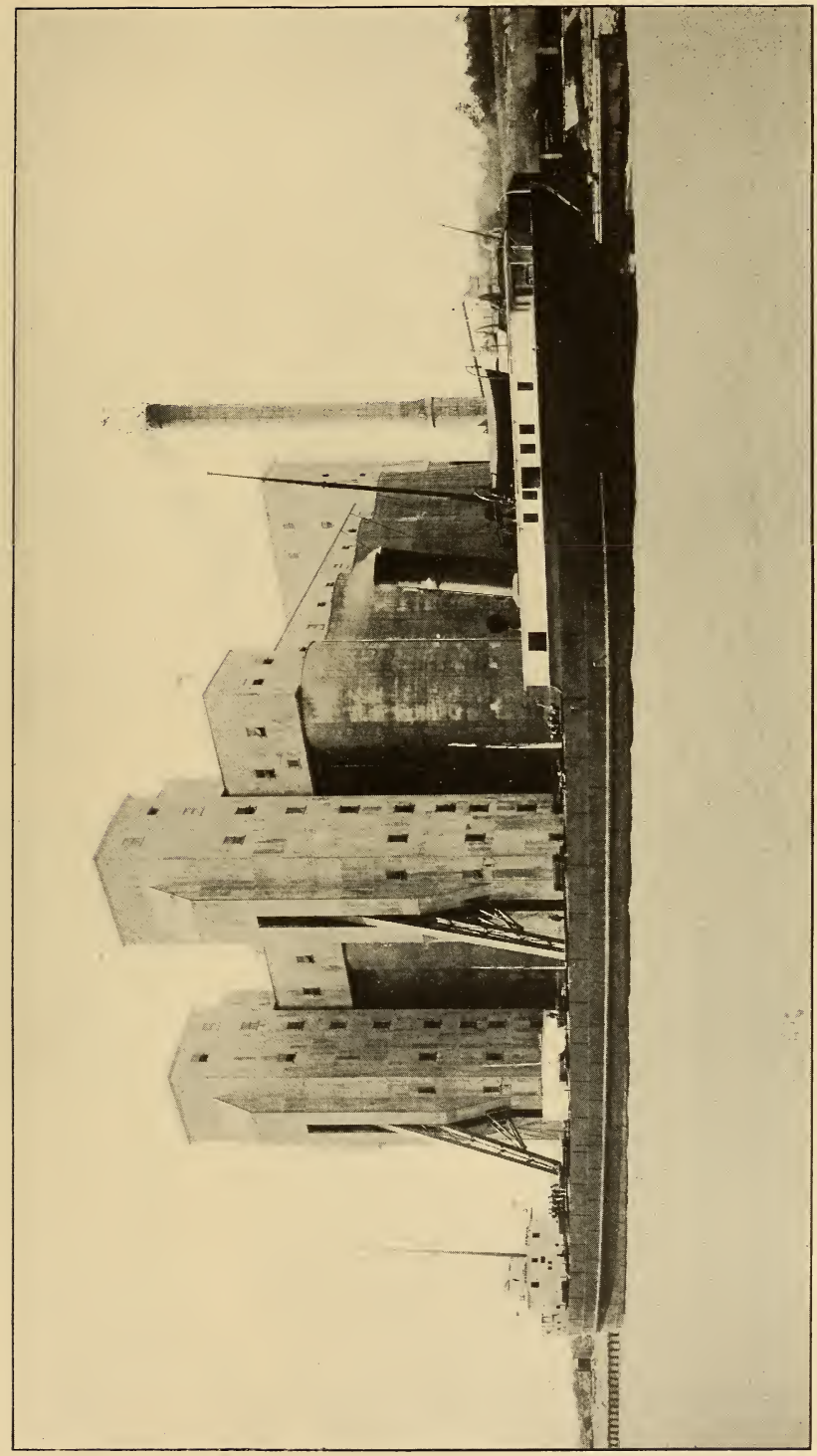
posing the main structure is reinforced concrete. It was designed and the material selected by the noted elevator builders and designers, the John S. Metcalf Company, of Chicago. It is provided with docks and conveyors that will unload at the same time two of the largest steamers that ply on the Great Lakes, having a complete equipment for handling and transferring the grain. The unloading is performed by two "legs" which are lowered into the hold through the hatches, one leg forward and one in the after hold.

These legs are each nearly 100 feet in length. As the grain reaches the head of the tower leg, it is "shot" directly into a receiving bin. Beneath this bin is a weighing scale. The scales are set for a certain weight, and the weighing hopper is filled by pulling a lever which moves a slide in the bottom of the receiving bin above. The man who does the weighing is so expert that he can fill the scale hopper with the exact amount, no more or less, once in every fifty seconds, which he must needs do when the marine legs are pumping grain out of the hold at the rate of 5,000 bushels per hour.

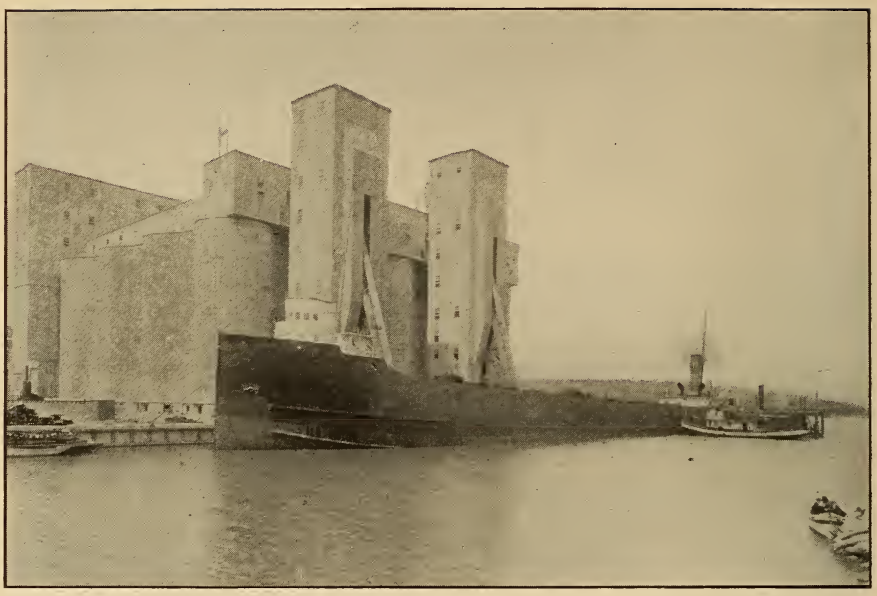
From the weighing hopper the grain is delivered direct to the storage bin; or, if it be destined for transportation across the sea, it will be carried across the building and out again by the railway to accommodate it. This type of elevator is similar to several other large storage plants built in inland cities for railway service. They are also built of reinforced concrete, the bins being circular in form, are of great strength, and of thoroughly fireproof construction. The square tower-like building contains the elevating, cleaning, weighing and conveying machinery. At about the middle height of this building horizontal covered passageways serve to contain conveyor belts, by which the cleaned and weighed grain is transferred to the top



SPOUTING AND BELT CONVEYOR IN WORKING HOUSE IN GRAND TRUNK PACIFIC ELEVATOR, TIFFIN, ONT.



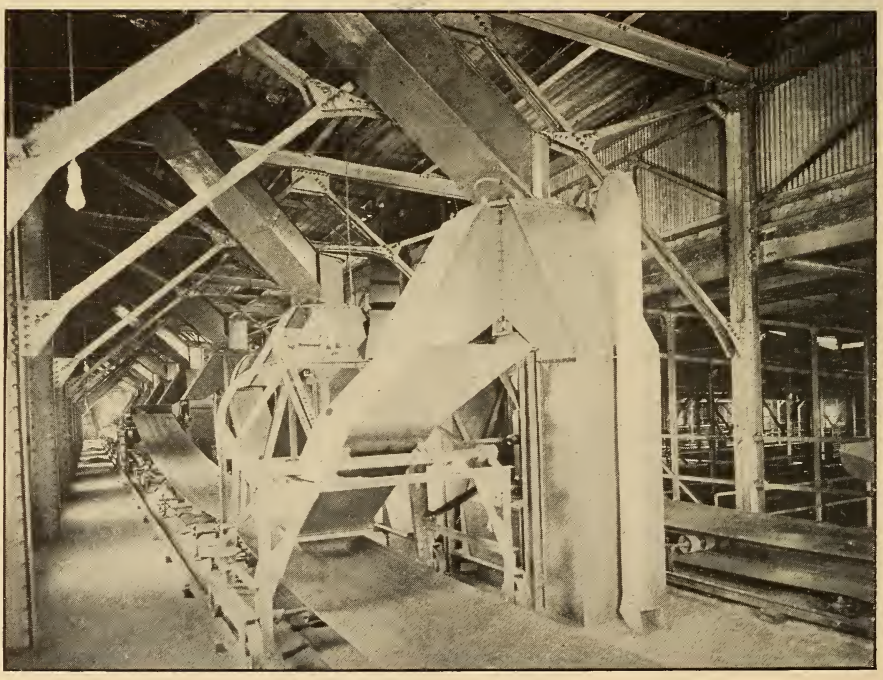
STEAMER MIDLAND KING UNLOADING AT GRAND TRUNK PACIFIC ELEVATOR, TIFFIN, ONT.



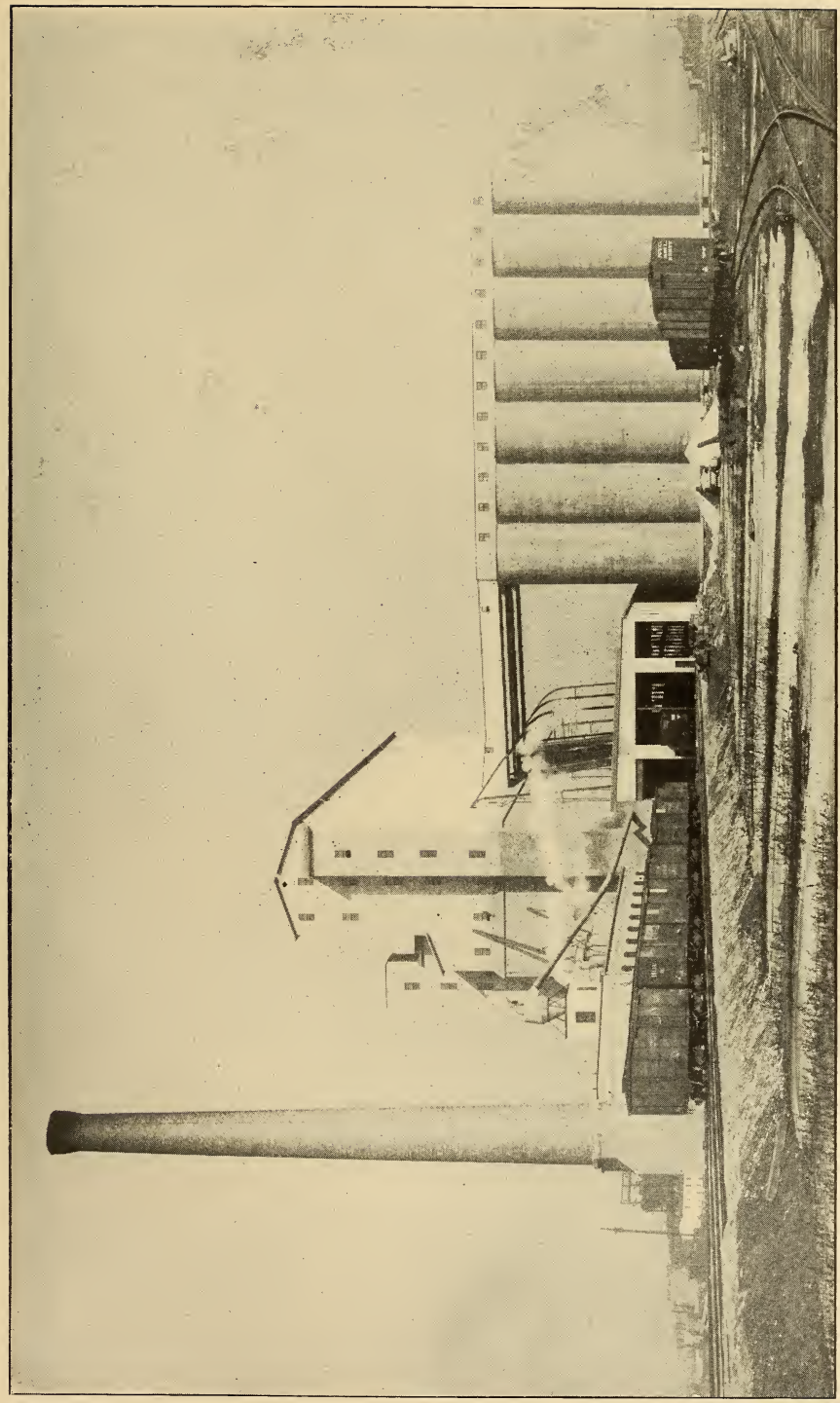
GRAND TRUNK PACIFIC ELEVATOR AT TIFFIN, ONT. CAPACITY, 2,000,000 BUSHELS

of the bins and loaded into the particular bin desired.

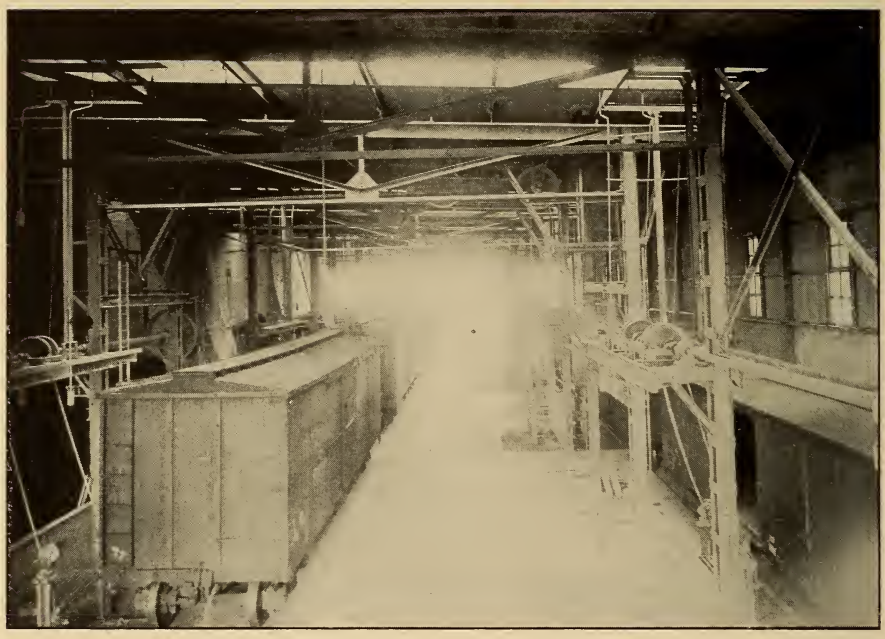
In storing wheat in the inland elevators, electric or steam power is utilized. The carloads are removed by what is known as a power shovel. This consists of a large two-handled scoop, to which is attached a rope that is wound upon a rotating cylinder. The drum is so fixed upon its shaft



BELT CONVEYOR ABOVE THE BINS AT THE TIFFIN ELEVATOR



GRAIN ELEVATOR OF THE ATCHISON, TOPEKA & SANTA FE RAILROAD, CHICAGO. CAPACITY, 1,400,000 BUSHELS

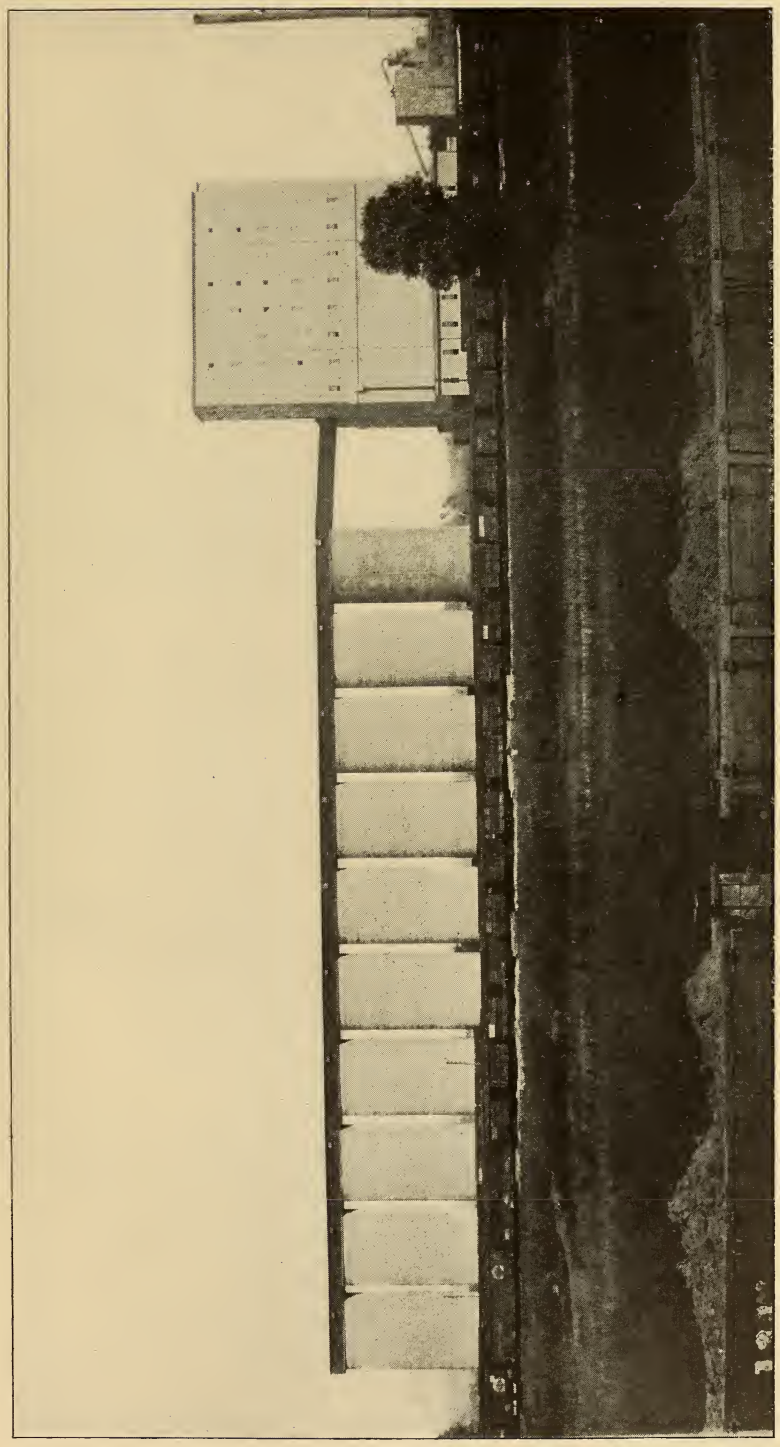


CAR UNLOADING SHOVELS, SANTA FE ELEVATOR, CHICAGO

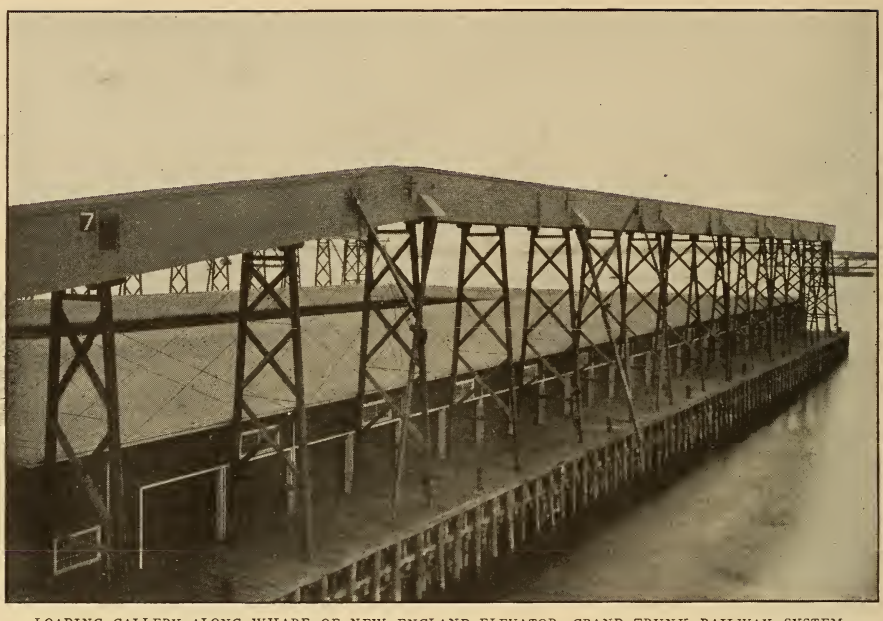
that when the man at the shovel walks away with the latter the drum readily unwinds, but as soon as he stops the cylinder commences winding in the rope and hauls the scoop back to the point at which it started. There are a pair of these shovelers to each car, and they carry the scoop back, bury it in the wheat, and guide it as it is pulled forward out of the door of the car and discharges its contents into a hopper that leads to the boot of the huge elevator leg. Two of these shovelers can unload from the cars 30,000 bushels of grain in a single day.

The transfer is another design of the modern elevator. It is located on the waterfront, where vessels in the export trade may be moored by its side and the grain loaded as fast as the elevator conveyors remove it from the cars, the railway being on the opposite side. If they are marine elevators the plans provide for running the grain-laden cars directly into the structure, tracks being laid along the ground floor of the building. If the location is such that this plan is impracticable, the track is laid alongside, and from openings in the buildings project the receiving legs or spouts, which are from 15 to 25 feet in length, hinged, so that they can be hoisted against the side of the building when not in use. The end of the spout is carried into the car by the feeder, who moves it from place to place as the contents of the car are emptied. With the spouts in modern use all of the grain with the exception of a few shovelfuls can be taken out, so that the only human labour required is that of the feeder. As an ordinary leg will elevate from 9,000 to 10,000 bushels an hour, a trainload of thirty or forty cars, representing 1,500 tons, can be passed into the building in this time if it have the average number of receiving spouts.

The grain is conveyed to the top compartment, to be held until it flows into the cleaning hoppers, thence to the scales, thence to the distributing or marine legs. The latter are much larger than the receiving spouts, as one is allotted to serve a hatchway. They have an average capacity of from 20,000 to 25,000 bushels an hour



ELEVATOR, DRYER HOUSE AND TEN STORAGE TANKS; MISSOURI PACIFIC ELEVATOR, KANSAS CITY, MO. CAPACITY, 1,000,000 BUSHELS



LOADING GALLERY ALONG WHARF OF NEW ENGLAND ELEVATOR, GRAND TRUNK RAILWAY SYSTEM, PORTLAND, MAINE

and are adjustable, although the cargo must be properly trimmed by the stevedores. So rapidly does one of the elevators transfer its contents that the first of a carload of wheat may be deposited in the hold of the vessel on the other side of the structure before the last bushel has left the car itself.

The storage elevators are divided into bins of various sizes, with a view of distributing the weight as evenly as possible upon the foundation of the building, and also equalizing the side pressure on the walls. In the wooden structure the bins are square in shape, extending from the top to the ground floor, and are usually massed in the center of the building. As much of the machinery as possible is installed in the cupola, with the exception of the power plant, which, in the steam-driven elevator, is generally located in a separate building as a precaution against fire and as a matter of convenience.

The plan followed in the elevator construction of to-day is usually to locate the distributing department next to the bins, above it the scale room, above this the cleaning garners, the shafting and other transmitting machinery being placed at the top. In receiving grain the same method is employed as in the transfer elevator, the contents of the car being carried to the top of the building. In this process and in transmission to the other compartments the systems employed include suction through wood or metal conduits to which are attached exhaust fans, thus creating a partial vacuum, or the use of conveyors. The latter are generally composed of endless belts carrying buckets made of sheet metal, which fill and discharge automatically as the belt moves. The belts are used also for carrying away the screenings from the machinery. The dust and other fine particles are usually removed by an air current produced by a fan and conveyed outside of the building through special spouts. It may be said here that the transfer capacity of the machinery is so adjusted to the different departments in a modern elevator that it is not necessary to stop the machinery at any time to regulate the movement of the grain.

The rapid increase of grain com-

merce on the Great Lakes, due to many of the United States and Canadian railway systems being built to them, has caused some of the most capacious grain storage stations to be recently constructed on the Canadian and American shores. This group is notable for not merely the quantity of grain it will hold, but for its modern equipment, especially the facilities for the fast loading and unloading of cars and vessels.

While the great Northern elevator already described is one of the largest in the world, it is rivalled by such plants as the Grand Trunk Pacific elevator at Tiffin, Ontario. Built of concrete and steel, it represents the latest design of construction, including steel storage tanks, and electrically actuated marine towers. It has a capacity of 2,000,000 bushels. The two marine towers each have a maximum unloading capacity of 20,000 bushels per hour. The car-loading capacity is 300 cars in ten hours. A 1,200 horse-power steam turbo-generator plant operates motors of 30 horse-power to 125 horse-power, belt conveyors and elevators of 15,000 to 20,000 bushels per hour. The working house is 192 feet by 24 feet, and storage house 238 feet by 178 feet. Seven hundred feet of concrete wharf has been built for marine service. The photographs show the great size of this elevator.

The Tiffin was designed and constructed by the John S. Metcalf Company, of Chicago, and represents the latest type of elevator. Another completed by the same company for the Atchison, Topeka & Santa Fé Company, at its Chicago terminal on Lake Michigan, has a working house of 400,000 bushels capacity, a storage house of 1,000,000 bushels capacity, and unloads 200 cars in ten hours. It is equipped to load cars or vessels. The elevators and conveyors have 15,000 bushels per hour maximum capacity. There are also grain drying and bleaching plants. This is operated by steam power. Another Great Lake elevator is located at Victoria Harbour, Ontario, a terminus of the Canadian Pacific. One of the Metcalf plants, it equals the Tiffin in capacity, with a storage space of 2,000,000 bushels. It is constructed of concrete and steel with two moving marine towers, each with capacity for unloading 20,000 bushels per hour maximum. The loading capacity is 200 cars in ten hours. The elevators and conveyors handle 15,000 bushels and 20,000 bushels hourly. The plant comprises a 1,500 horse-power steam turbo-generator plant with motors 5 horse-power to 125 horse-power. The working houses are 96 feet by 28 feet and storage house 238 feet by 178 feet.

One of the largest elevators on the Lakes is operated by the Grand Trunk Pacific at Depot Harbour, Ontario. It has no tank storage, but is a single structure holding 1,750,000 bushels when filled. Its marine leg is of such capacity that it will unload 12,000 bushels an hour.

An inland grain storage depot built for the Missouri Pacific at Kansas City, is of interest because its storage house is a series of steel tanks holding 720,000 bushels, in addition to 280,000 bushels for the working house. Its conveyors have a maximum capacity of 15,000 bushels per hour. It is operated by steam power and provided with a grain-drying plant. The modern type of the gallery elevator is to be seen at Portland, Me. Here the gallery is necessary to serve ocean carriers on account of the depth of water. Cargo transfer is performed by means of an endless conveyor. The system is similar to that of the Illinois Central elevator at New Orleans, where the gallery conveyor is nearly a half mile in length from the elevator to the levee on the Mississippi River.

THE NEW INDUSTRY AND THE OLD INEFFICIENCY

HOW THE ENGINEER IS APPLYING SCIENTIFIC METHODS TO AGRICULTURE

PREFATORY EDITORIAL NOTE

"IT all comes out of the ground!" Upon the produce of the soil the whole population of the world is dependent for its food. Every year the army of non-producers awaits with intense anxiety the crop reports, looking for the news of the new wealth upon which dependence must be placed for food and for business.

This master industry, constituting forty per cent. of the invested capital wealth of the country, is still being conducted in a primitive and inefficient manner. The men engaged in feeding both the producing and non-producing portion of the population are working at an immense disadvantage, as compared with the manufacturing and transportation industries, and with the increase in the demand for subsistence and the decrease in the proportion of workers in the fields, the cost of food is being continually forced upward.

There is in this situation great reason for encouragement! Here, immediately before us, lies the greatest opportunity which has yet been placed in the hands of an active, ambitious, and indomitable people!

The developments of the steel industry, of the electrical industry, of the automobile industry, fade into insignificance before the prospect of the exploitation of this, the greatest field for commercial and scientific success which the world has yet offered.

A practically unlimited market, an industry almost primitive in its inefficiency, a scope afforded by three hundred million acres of land serving one hundred million people—this is the opportunity!

The resources of the engineer, the capitalist, the scientific administrator, when applied to this waiting opportunity, must produce results and create new values beside which all that has yet been accomplished in directing the great sources of power in Nature to the use and convenience of man must become secondary.

Realizing that there is here a subject of controlling importance to every citizen of the United States, the editor of CASSIER'S MAGAZINE has arranged for the publication of a series of articles devoted to the various phases of what may rightly be called

THE NEW INDUSTRY,

the industry of producing new wealth from the ground at maximum efficiency, by the application of scientific methods of directing power, utilizing capital, employing transportation, and guiding research.

The first of these articles, entitled "The New Agriculture," has been prepared by Dr. Edward A. Rumely, and follows immediately.

Other articles will follow in succeeding issues of CASSIER'S MAGAZINE. discussing such subjects as: "The Replacement of Men and Animals by Power Machinery," "Methods of Increasing the Productivity of Present Acreage," "The Power Tractor and its Work for Agriculture," "Relations Between Agricultural Development and Transport," "Possibilities in the Development of New Food Plants," "Local Residence Centers in Agricultural Districts," "Developments in Agricultural Education," etc.

THE NEW EFFICIENCY

Plowing, Seeding and Harrowing at One Operation Behind a Power Tractor Fed by Kerosene

THE NEW AGRICULTURE

HOW THE FARM IS TO BECOME A WORKSHOP IN METHODS, EQUIPMENT AND PRODUCTIVITY

By Edward A. Rumely

The following article, dealing broadly with the general problem of the application of modern business, educational and engineering methods to the development of the production of food supplies from the soil, is based upon an address delivered before the second annual conference of the Bankers' Committee on Agricultural Development and Education, at Minneapolis, on August 7, 1912, and has been in part rewritten and fully revised by the author for publication in this place.—THE EDITOR.

ACCORDING to the estimates of the Census Bureau of the United States, the greater portion of the wealth and industrial activity of the nation is distributed among three principal divisions, both as regards capital investment and as regards resulting income. These three great divisions are: Agriculture, Manufactures and Railways. Together, they account for more than 70 per cent. of the total wealth of the nation, and upon them its life and prosperity depend. Until a period well within the past century the railway industry did not exist; within a period of less than two hundred years manufacturing, in the modern sense of the term, has been wholly created; while from the earliest dawn of history agriculture has existed.

Surely it is a matter for thoughtful consideration that, by the application of manufactured power to the transformation of raw material and by the application of manufactured power to transport, two industries have been enabled to take rank in a comparatively few years by the side of the oldest department of human activity.

If the application of manufactured power by group effort has thus been able to produce such tremendous developments in these industries, we may well direct attention to the possibilities resulting from similar application of power to the older industry of agriculture.

Mankind has come into possession of new tools. The steam engine has attracted all productive activities from

the home and centered them in vast factories. It has built up cities. Rapid and cheap transportation has enabled the still further centralization of productive effort into larger units. Engine power is so much cheaper and more effective that men throughout the civilized world have assembled near it so they may use it in all their work and as part of the daily routine of living. A still further increase of human power came as we learned that ten men, working together, are vastly more efficient than ten individuals working singly. When a thousand men are united for a common purpose their power has increased almost in geometrical ratio.

To-day, in consequence, we are attacking problems of such magnitude that before them single individuals would be powerless. The corporation is the institution created within the last century to focus the endeavour of large numbers to a common end. Corporations have grown in size from decade to decade until they have become national and international in their scope, dealing successfully with problems that would have appalled our forebears of only a generation ago.

With this growth to greater and greater size, the corporation became a factory of such importance to the life of each citizen that the feeling spread among the people of all countries that the State, representing the people as a whole, must step in to define the principles, limit the scope, regulate, and prevent the abuse of the power that has been acquired by such corporate groups. This new function of regulating corporations has given the public officials in charge of our government an authority and influence reaching intimately into our business activities.

When the Republic was founded, four generations ago, our forefathers, scattered along the Atlantic seaboard, were but a few millions in number. To their west lay a whole virgin continent, richer in soil fertility, timber, ore, and other natural resources than any land the white man had ever found. With energy and shrewd intelligence, they took possession and exploited these stores in a gigantic way. The fur-bearing animals were killed. The timber was cut and sawed into lumber for use at home and sale into export markets, with mills that could handle a million feet a day, operated by the labour of few men. Improved methods of mining by machinery enabled a few men to handle vast masses of ore and metal. Faster and faster the prairies were broken and seeded to wheat, partly because wheat can be easily transported, but mainly because in the value of wheat there is not merely the labour of producing it, but also a content of valuable soil salts in which we have been selling the fertility of our virgin prairie in European markets.

In 1830 the work of growing a bushel of wheat on the farm required three hours of human time. To-day, due to the introduction of improved machinery, a bushel of wheat contains only 10 minutes of labour value. In other words, the unit of soil salts, worth over 20 cents in each bushel, sufficed to furnish employment for three hours; while to-day the wheat-selling farmer must part with that amount of his soil capital to sell ten minutes of his labour—a development of 1,800 per cent. in the wrong direction.

The first or colonial period of our history is now at an end. We are a hundred millions in number. Our open West is gone. The country is occupied. Our population is spread until cities have touched the Pacific. Already our timber is half cut, and we have calculated that within another generation at the present rate of consumption the last of our forests will be gone. We are mining our iron, our copper, our lead and other metals more rapidly than any other country in the world. The pioneer farmers who worked the soils of the South with tobacco and of the East with wheat can no longer move off to

the West when, having exhausted the fertility of our lands, they find farming no longer profitable. The hundred thousand vigorous Americans who went last year to Canada with energy, capital and American tools are a concrete evidence that we have reached the end of the course which we have been traveling. The whole country has been startled by the warning of far-sighted men, and now the demand for conservation of our natural wealth is becoming more and more insistent. We have been made to realize that every child born brings a mouth that must be fed, a body that must be sheltered and clothed, but no increase in natural wealth. We must still learn that every child does bring two hands, which can work, and which, when highly trained and backed by scientific knowledge, can create untold values. Stated otherwise, we must care for our increasing population, not by increased exploitation of our natural stores, but by providing abundant work for skilled labour.

Our country's four principal exports are still cotton, copper, wheat and mineral oils, all articles of natural wealth. We export chiefly these and relatively crude products partially manufactured with coarse machinery and unskilled labour—articles the price of which arises largely from the natural wealth with but a small content of labour values. We ship abroad hundreds of thousands of tons of steel at one cent per pound and copper at twelve cents per pound; and we buy back magnetos made of these same metals from Germany at one dollar and a half per pound. In exchange for steel rails at 1 cent per pound, we buy back scientific instruments at $10 per pound, $9.90 being the labour added to the ten cents' worth of metal.

To France we sell metals, wheat, barley, cotton, oils; and get in return champagne, laces, vichy water, amusement for our foreign tourists and education for our students. The silk that she sends us she herself has imported in a raw state from foreign countries, adding value to it merely through the skill of her workers and the design of her artists.

To England at nine cents per pound we sell raw cotton with its content of fertility from our Southern soils, cotton that she spins and weaves for the world's markets into cloth worth $1 per pound without touching a single resource of her own land.

To Italy we send a million bushels of wheat, and Caruso comes to sing for us a few months in return.

A survey of our national activities reveals one significant fact: we are still bartering away the solid things of the earth in return for the use of capital, business and labour values and personal service of other peoples. Our forefathers, with a virgin continent behind them, could well afford to do this; but for us that time is long past. Our whole economic policy from now on must aim to create values out of labour in the cities by building up secondary industries that take the raw materials and convert them into highly manufactured products. Instead of selling our steel and lumber in the raw state at one cent per pound, we must sell our iron in reapers and engines at ten cents per pound, in automobiles at fifty cents per pound, and in typewriters and cash registers at two dollars per pound.

This same ideal of selling labour instead of natural wealth is binding upon the farm. We do not need better agricultural education to increase the wheat crop from 13 to 30 bushels per acre merely for the sake of increasing our total yield of cereals. I doubt with our present population whether it would be a good thing to increase the yield of wheat from 13 to an average of 30 bushels per acre for the sake of growing seventeen hundred million bushels annually instead of seven, for that would simply hasten the day of soil exhaustion. Our aim should be rather to get the same amount of

cereals from a smaller acreage, so as to leave more land free for other varied crops. The ideal of selling labour values is binding for agriculture exactly as for other manufacturing industries. The more highly refined the farm product, the more labour and intelligence it contains, the greater its value in dry substances per pound and the smaller the drain it entails upon the soil of the farm from which it came. Instead of cereals at 60 cents per bushel, the farmer must sell cattle at 8 cents per pound, and he will get for each pound of soil salts forty times as much return. In butter, eggs, cheese and fruits he sells his labour and his personal effort rather than his soil values.

Of course, we want to increase our acre yield to the highest profitable limit, so that we can grow our national quota on the smallest area, thereby releasing acreage for other crops, through which, with much less drain on our soil fertility, the farmer can market large values arising from labour, a larger capital investment, and intelligent management.

The degree to which the farmer is successful in reaching this ideal of selling his labour measures the approach to a balanced state of agriculture that will leave each acre of land at the end of the year as fertile as at the beginning.

We must cease looking upon our land as an object which has us as transient masters. Instead, the passing years must teach us to love our soil as the European owner does the few acres that he has inherited from his father and in which lie all the past traditions of his family. In the soil we must see our great and permanent possession that is to be preserved, built up and made more fruitful for our children in coming years. If we accept as a national ideal the demand that we live by the labour power of our people we must quickly become a nation of skilled workers in the city and upon the farm, for crude and unskilled effort will not support us in our present standard of living. It is comparatively a simple thing to farm by machinery for wheat on the virgin prairie; but to carry on intensive agriculture in accordance with scientific principles under a system of crop rotation, using a great equipment of tools, with large stocks of well bred cattle, growing a great variety of plants and fruits, supplying from year to year the needed fertilizer to the soil, requires special skill and much technical knowledge.

The routine of tradition will no longer suffice. The sciences of chemistry and physics, acquaintance with botany and some of the other elemental laws of plant life, mechanical skill in handling tools and machinery, are a necessary part of the equipment for successful farming. The knowledge that underlies this is of recent development, but is not yet a common possession of the farmers of this country; hence, not knowing himself, the father cannot impart adequate training to his son.

Until a hundred years ago the production of food still centered largely in the family. The advent of the steam engine and the introduction of new tools and machinery called for a broader group than was possible within the family circle. Corporations were organized to control factories.

Public welfare demands that our methods of farming be changed, and the broader agricultural education that we are seeking will make possible the introduction of new methods upon our farms. It must be borne in mind, however, that they will necessitate the employment of vastly increased capital. Actually the American bankers and financial centres are facing a task that exceeds that of fifty years ago, when thousands of millions had to be poured into railroad construction. The investment to be made upon farms will be a long-time investment, and cannot, on that account, be taken from the deposit funds of our banks. Ten dol-

Kind of Produce.	Approximate Maximum Yield per Acre.	Pounds Chemical Elements.			Nitrogen.	Value per Acre.			Farm Value of Product.	Percent Soil Fertility in Total Farm Value.
		Nitrogen.	Phos.	Potas.		Phos.	Potas.	Total.		
Corn—										
Grain	100 bu.	100	17.	19.	$15.00	$2.04	$1.14	$18.18	$60.00	....
Stover	3 tons	48	6.	52.	7.20	.72	3.12	11.04	18.00	....
Corn Crop	...	148	23.	71.	22.20	2.76	4.26	29.22	78.00	37.5
Oats—										
Grain	75 bu.	45	7.	9.	6.75	.84	.54	8.13	30.00	....
Straw	2 tons	24	4.	40.	3.60	.48	2.40	6.48	12.00	....
Oat Crop	...	69	11.	49.	10.35	1.32	2.94	14.61	42.00	34.4
Wheat—										
Grain	40 bu.	46	6.	11.	6.90	.72	.66	8.28	34.00	....
Straw	2 tons	19	4.	34.	2.85	.48	2.04	5.37	12.00	....
Wheat Crop	...	65	10.	45.	9.75	1.20	2.70	13.65	46.00	29.7
Timothy Hay	2 tons	48	6.	47.	7.20	.72	2.82	10.74	30.00	35.8
Apples	600 bu.	47	2.	57.	7.05	.24	3.42	10.71	600.00	....
Leaves and Wood	...	65	9.	52.	9.75	1.08	3.12	13.95	.....	....
Apple Crop	...	112	11.	109.	16.80	1.32	6.54	24.66	600.00	4.1
Potatoes	300 bu.	63	13.	90.	9.45	1.56	5.40	16.41	225.00	7.3
Sugar Beets	20 bu.	100	18.	157.	15.00	2.16	9.42	26.58	100.00	26.6
Fat Cattle	1,000 lbs.	25	7.	1.	3.75	.84	.06	4.65	70.00	6.6
Fat Hogs	1,000 lbs.	18	3.	1.	2.70	.36	.06	3.12	45.00	6.9
Milk	10,000 lbs.	57	7.	12.	8.55	.84	.72	10.11	75.00	13.5
Butter	500 lbs.	1	0.2	0.1	.15	.02	.01	.18	125.00	0.1

The above table is worked out for maximum yield conditions with nitrogen figured at 15 cents per pound, phosphorus at 12 cents, and potassium at 6 cents. Observe in this table, which is largely based upon the work of Dr. Hopkins at the University of Illinois, that for every dollar's worth of elements taken up by the plant, there results in corn $2.67 in total farm value of marketable product; in timothy hay, $2.79; in oats, $2.88; in wheat, $3.37; in sugar beets, $3.76; in milk, $6.43; in potatoes, $13.71; in hogs, $14.40; in fat cattle, $15.06; in apples, $24.33; and in butter, $700.

The higher the labor content of a product and the greater the amount of skill required to produce it, the larger its value in proportion to the unit of fertility contained. Take, for example, the case just shown, where if the farmer refines his milk into butter on the farm or buys back his skim milk, he makes his unit of soil fertility go 109 times as far; or sugar beets, where, if he follows the German practice of feeding the refuse from the sugar factory on his own farm, a unit of his soil fertility will bring him, instead of $3.76, approximately $1,000 in value.

lars per acre must be invested in artificial fertilizers, manures and crops plowed under to bring back to fertility the worn lands. For one hundred million acres this would mean a billion dollars, and it would require five years for plants to extract the fertilizer so placed, even if we should be willing to accept a plan of bringing on soil exhaustion again in five years instead of permanent improvement. More farm machinery and more special tools must be employed to save labour in proportion to total output, and thereby offset the difficulty of securing farm help, until our new education shall have created such enthusiasm for farming as will bring a sufficient number of capable and willing workers.

The per acre investment in machinery ranges from three to seven dollars at present. It must be increased to from twelve to fifteen dollars per acre—or a total, on three hundred million acres, of two billion dollars.

In cattle raising, a calf must be purchased and kept for two years before it is ready for the market. Cattle must be purchased and buildings must be erected to care for the stock, and for this an additional investment of from one and a half to two billion dollars will be required. In other words, as soon as the problems of agricultural education have been solved we must devise avenues of credit by which five thousand millions of additional long-time money can be made available from the world's cheapest credit markets for American farm operations.

In this connection I may relate two incidents encountered during my student life in Germany.

Once, while on a walking trip through the Black Forest, I came to a little village school on a warm July day. The teacher and fifteen little 11 to 13-year-old German boys, some with big patches on their trousers, were standing in a group not far from the building. A general examination was going on.

In reply to the question of the teacher, a little voice said:

"We planted the seed, and it started to grow, and the roots reached down into the glass for food, and it spread its leaves into the air to catch the sunshine and to breathe."

As I looked I saw a row of glasses in the school window, in which seeds were germinating and in various stages of growth. Just then a wagon loaded with wheat sheaves that were being hauled to the community threshing machine in the village passed by the school. The teacher sent one boy to fetch a bundle of wheat. He laid it on the ground and set fire to it, as he explained: "This fire will make each part of the plant go back to where it came from. The heat and the light will flow off into space toward the sun, from which they were gathered, and the smoke, containing the coal stuff (carbonic acid) will go back into the air." And then he pointed to the ashes, and asked one lad where they came from. The answer was, "From the ground." "But how did they get there?" "The roots picked them up; they were in the water that plants suck up, and as the water dried up in the straw and leaves, these remained behind." "What are these ashes?"—and another lad answered: "They are the minerals that are the strength of our soil and that make the plants grow." "What is your father doing," he asked, pointing to a wagon loaded with wheat sheaves that was passing. "He is hauling away the strength of the soil," another little voice said, "but when he hauls the manure back from the stable he will put all the straw back on the soil."

Such lessons impress themselves upon the minds of ten-year-old children indelibly and make of them the skilled and efficient German farmers of to-day.

Another time, as a student at the University of Berlin, I was listening to a lecture by the professor of economics. He was discussing the State policy that underlay certain

taxation laws, and bounties upon sugar and alcohol.

"Yes, we must conserve our soil fertility. Those products which drain the soil most of its permanent values we must import from abroad. If we buy cotton meal in America and feed the cattle here, the whole value of the meal is retained in the price of the meat, while vast quantities of fertilizers, containing the essential soil salts, remain upon the farm and enhance its fertility. In every million bushels of wheat that we purchase from America there are 1,575,000 pounds of nitrogen, phosphorus and potash, worth, in round numbers, 1,068,000 marks, or $267,000. These are drawn from the virgin prairies of America and other new lands. A portion of the fertilizer value of this wheat is retained through our systems of city sewage farms to enhance the fertility of our German soil. In disposing of products of the farm, we must strive to market such articles as meat, which contains but 30 per cent. of solid matter and only 2 per cent. or 3 per cent. of mineral salts; cheese, and especially the carbohydrates, such as butter, alcohol and sugar. The sugar beet farmer feeds the refuse of his beets to cattle, and the manure goes back to the land. In alcohol production, only the alcohol is sold from the place, while the protein, containing the mineral salts, is fed and retained there. The extent to which the farm values we sell are attached to carbon in place of to the soil salts that exist only in limited quantities is a measure of the degree of our agricultural development."

And it is this German art of selling labour in place of natural wealth that we Americans now have to learn.

Plants have become plastic in our hands, like clay. We can mould their forms to suit our needs. All the domesticated plants that are the basis of our present agriculture are man-made—the result of age-long unconscious effort on the part of our forebears. With the scientific knowledge that has come within the last sixty years, since Charles Darwin, we are able to take hold of plant life and accomplish in a single decade more than untold generations before. The potato, upon the development of which the Indian probably worked thousands of years and which was cultivated in Europe for three hundred years since the time of Sir Francis Drake, has been re-created in a single decade by conscious effort of French gardeners.

Wheat originally was a seed as tiny as the seed of hay—two berries to the stalk. It has been made by man what it is. The adding of but a single grain to each head would add 5 per cent. to our annual wheat crop, thereby without any increase of effort producing an annual revenue of $25,000,000.

The possibilities of plant life have hardly been touched. There are hundreds of thousands of botanical forms upon which no conscious method has been used by man. Our forefathers at the time of the Revolution hoped to lighten the drudgery of human life by stimulating, through patent legislation and the development of schools and technical knowledge, the use of machinery and mechanical inventions. Hundreds of thousands of men have spent their lives to promote these ends. The effort to promote better schooling and greater technical knowledge that started with those enthusiasts for humanitarian ideals who framed the Constitution has achieved their desired results. The age of machinery is here. It is for us now to recognize the possibilities of forwarding plant life so as to make it serve better human needs and by a similar broad agricultural school system create an army of men to attack this problem.

To sum up, then, we have arrived at a period that is almost critical in our country's history.

(1) We must change the industries of our cities and the methods of our farming so that henceforth we shall sell the labour power of our

people rather than the natural wealth of our land.

(2) In order to make all labour effective so that it will create large values, we must have vocational training that will fit directly for life's work. City children must gain skill and knowledge for industrial effort, and the children destined for the farm must have in their schools a broad training that will give them understanding of the scientific principles as well as skill and enthusiasm for the work itself.

(3) This vocational training, or work, is needed for the child's own intellectual and moral development, and must be included in all primary schools on that account alone. Our forefathers, in their struggle toward civilization, had for ages to work with their unaided hands, and this period must be repeated in the life of every child. Nation-wide results cannot be achieved by mere devices such as demonstration plots, prize contests, propaganda leaflets—all of which are good, but not sufficient to modify profoundly the mind of one-half of our whole population.

(4) Teachers consciously prepared for this new work by years of special training are our most urgent present need.

(5) To set the standards, develop proper methods of instruction and equip the first teachers in large numbers for this new work, a central normal school should be developed by the joint effort of manufacturers, bankers, railroad men and other citizens interested in either the cultural or practical aspect of work as part of the regular school curriculum.

As these are realized we shall have the education of the whole child. Training for work will emphasize the civic consciousness by making every citizen feel that he has his useful part to do. .On the farms there will be less soil robbery and in our factories a rapid development to quality production. The skill and forethought implied in this will lead to broader national culture. As the standards of manufacture and agriculture rise we shall rely less upon our national wealth, for, by selling our labour instead, we can conserve for future generations our soil fertility.

Agriculture has been a process of mining. We need the new education so that the farm may become a workshop, furnishing a field for skilled labour, intelligent management and the profitable employment of capital.

When we perceive the results which have followed the application of the scientific methods of engineering to the manufacture of iron and steel, to the production and control of electricity, to the construction and operation of railways, and to the perfection in design and manufacture of the automobile, we may form some idea of the consequences of the creation of a new agriculture, an agriculture in which manufactured power shall replace the efforts of man and horse, in which the full fertility of the soil shall be developed by working it to much greater depths than heretofore, and in which scientific methods shall restore that fertility continually and effectively.

THE OLD INEFFICIENCY

PROPELLERS FOR AEROPLANES

RESUMÉ OF THE EXPERIMENTS MADE AT THE LABORATORY OF THE CHAMP DE MARS

By G. Eiffel

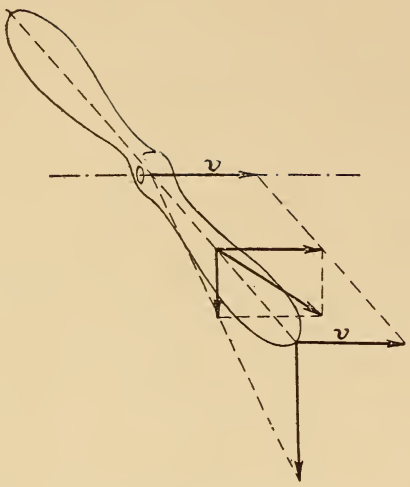
The authoritative and quantitative work which M. Eiffel has been conducting for a number of years upon matters relating to atmospheric resistance and allied problems, in connection with his remarkable laboratory on the Champ de Mars, at the great tower of 300 metres, has especial value in connection with the development of the aeroplane. During the past two years M. Eiffel has been making especial researches both at the Champ de Mars and in his new special laboratory at Auteuil, upon the performance of propellers used in aeroplanes, and upon the behaviour of model aeroplanes of various types. The results of some of these investigations have been communicated by M. Eiffel to the *Societe des Ingenieurs Civils de France,* and an abstract of the special experiments upon propellers is here given as being of especial interest in connection with the article of Mr. Emerson upon Speed Limitations in Aeroplanes, in our October issue.—THE EDITOR.

THE present experiments upon aeroplane propellers here recounted must not be regarded as final, but rather only as preliminary. It will be necessary to extend them to rotative speeds of 3,000 to 4,000 revolutions per minute, and to be able to place the model in air currents reaching 15 to 30 metres per second, for which purpose the equipment of the new laboratory at Auteuil will be available. Nevertheless, the results which have already been attained will be found of interest, and will be followed as soon as practicable by others of fuller scope.

The experiments consisted in employing an electric motor to cause reduced models of propellers to revolve in the midst of a current of air of a known velocity. The principle of relative motion thus enables us to obtain conditions similar to those obtaining if the propeller itself was moving through still air. This method gives the best opportunity for determining accurately the velocity of the air current, the number of revolutions of the propeller, the thrust, and the resisting couple—that is to say, all the elements involved in the performance of the screw.

The apparatus employed at the laboratory of the Champ de Mars consisted essentially of an electric motor of two horse-power, upon the horizontal shaft of which the propeller to be tested was placed. This apparatus was supported upon two knife-edges, placed parallel to the shaft, and suspended from fixed points by wires. The horizontal displacement which the propeller tended to produce was transmitted by a rod to the aerodynamic balance designed by the writer, thus enabling the thrust to be measured. The resisting couple tended to produce an inclination of the apparatus about the axis of the knife-edges, this being measured by the movement of a needle point before a curved scale which had been previously calibrated by definite weighting. The number of revolutions was given at any instant by a speed indicator. The velocity of the air current was measured, as in other experiments of the author, by a Pitot tube. This air velocity varied between 5 to 18 metres per second (about 1,000 to 3,500 feet per minute), and for each of these velocities the speed of the electric motor could be varied from 400 to 1,600 revolutions per minute.

The results obtained by these tests may be represented by a method which we have used since the beginning of 1911, using two curves to present the complete performance, not only of a single propeller, but of all propellers of geometrically similar form. The ordinary method represented velocities of translation by abscissas, using the ordinates either for the power or the thrust. If a



DISTRIBUTION OF PROPELLER FORCES

number of rotative speeds are considered, a number of curves are required to show the performances of a single propeller. The method here employed, on the contrary, enables two curves to replace, in principle at least, an entire series of the former diagrams. The records are thus materially simplified, and it is believed that the adoption of this method will be of much service to those who are studying this question of propelling screws.

Following the analogy of fixed surfaces, it is admitted that the effort exercised by the air upon an element of propeller surface is proportional to the area of surface of this element, and also proportional to the square of the relative velocity; and upon these assumptions we deduce the following formulas:

Let us consider a propeller of which the diameter is our unit of length, and which is moving in a direction parallel to its axis with a velocity V. If, at the extremity of the blade, the velocities of rotation and translation vary proportionally, the diagram shows that for any point the relative velocity, which is the resultant of the two velocities, varies in the same proportion, and that its direction does not change. In other words, for a given direction of relative velocity at the extremity of the blade their relative velocity of any point of the propeller is invariably in direction, and its intensity is proportional to V. Under these conditions the efforts upon the blade have a resultant of fixed position and direction, and this resultant has an intensity ϕ proportional to V, or:

$$\phi = AV^2$$

In a propeller of geometrically similar form and of a diameter D, and of which the velocities at the extremity of the blade have the same relation, the resultant will be placed upon a homologous line, and its intensity Φ will be multiplied by the ratio of the surfaces $\frac{D^2}{1}$, whence:

$$\Phi = AV^2D^2,$$

an expression in which A is a coefficient dependent only upon the direction of the relative velocity at the extremity of the blades; that is to say, upon the ratio of the velocity of translation to the peripheral velocity, either $\frac{V}{\pi nD}$ or $\frac{V}{nD}$, n being the number of revolutions per second. We then have:

$$\Phi = V^2D^2f\left(\frac{V}{nD}\right)$$

which, since $V = \frac{V}{nD} \times nD$, may be written:

$$\Phi = n^2D^4f\left(\frac{V}{nD}\right)$$

From this expression all the fundamental formulas may be derived.

1. The intensity Φ projected upon the horizontal axis give the thrust, for which the formula is:

$$F = n^2D^4f\left(\frac{V}{nD}\right)$$

2. The components perpendicular to the axis give a couple of which the moment C is proportional to these components and to their distance from

the axis; that is to say, to the diameter of the screw:

$$C = n^2 D^5 f_2 \left(\frac{V}{nD} \right)$$

3. The effective power is the product of the thrust by the velocity:

$$P_u = n^3 D^5 f_3 \left(\frac{V}{nD} \right)$$

4. The motive power is the product of the couple by the angular velocity $2\pi n$:

$$P_m = 2\pi n^3 D^5 f_2 \left(\frac{V}{nD} \right)$$

5. Finally, the efficiency is the ratio between P_u and P_m:

$$P = f_4 \left(\frac{V}{nD} \right)$$

These five quantities:

$$\frac{F}{n^2 D}; \quad \frac{C}{n^2 D}; \quad \frac{P_u}{n^3 D^5}; \quad \frac{P_m}{n^3 D^5}; \text{ and } \zeta,$$

for any given propeller, or even for any propeller similar to a given type, depend only upon

$$\frac{V}{nD}$$

in such a manner that if we take the values of $\frac{V}{nD}$ as abscissas and these five quantities as ordinates, the five corresponding curves will represent the entire performance of the propeller, or group of propellers. It will really be necessary to trace only the first and the second of these curves, giving the thrust and the couple; or else the first and the fourth, giving the thrust and the motive power, since the other curves may be deduced from them. We thus have five curves, which may, in practice, be reduced to two in number, giving the performance of a propeller or group of propellers.

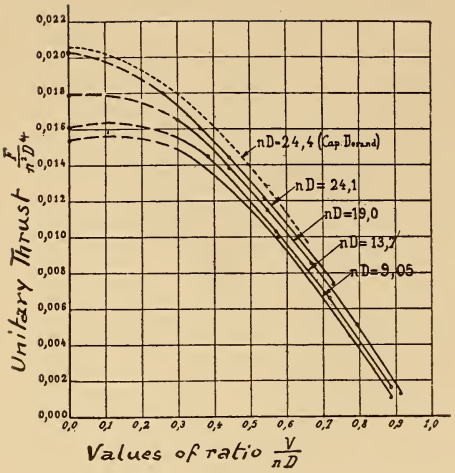
As a matter of fact, however, the operation may be made still simpler, as I have already discussed in another publication.

Previous investigations have assumed, as in the formulas just derived, that the effect of the air is proportional to the area of surface and to the square of the relative velocity of the wind and the propeller blade. It soon became apparent, however, that when marked changes in velocity occurred one could no longer consider the points as falling upon a single curve. By making very large variations in velocity, it became possible to verify the fact that there existed a different curve for each relative velocity or for each rotative speed of the propeller. It is true that these various curves were frequently close to each other. We may state, however, that for a given propeller the quantities such as $\frac{F}{n^2 D^4}$ did not depend solely upon the ratio $\frac{V}{nD}$.

We have received from Commandant Dorand a number of models of propellers tested by him. Experiments made with these models gave very different curves upon our diagrams from those made of the Chalais experiments. This shows that two propellers of different diameters, having the same value for the ratio: $\frac{V}{nD}$, do not correspond to the same value of $\frac{F}{n^2 D^4}$, etc.

The following remarks may aid in explaining some of these anomalies:

The relative velocity of the blade and the air is very great in the case of a propeller, so that we cannot safely assume that the law of proportionality to the square of the velocity is exactly maintained. This alone would suffice to explain why we obtain various curves for one and the same model, since, in order to obtain a single curve, it is necessary that the resistance should be proportional to the square of the velocity. This fact may also explain the differences obtained between the small models and



PROPELLER THRUST CURVES

the full-sized propellers which have been tried at relatively higher speeds. The direction of the variations which we have observed indicates that at high velocities the resistance increases more rapidly than the square of the velocity, so that we find the values of

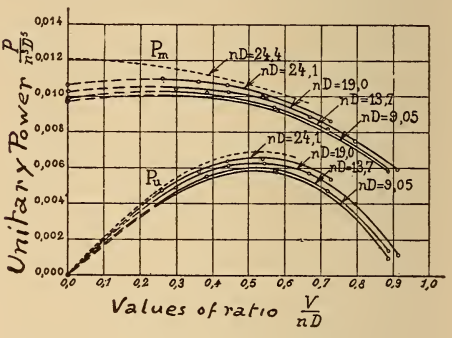
$$\frac{F}{n^2D^4} \text{ and } \frac{C}{n^2D^5}$$

greater at high velocities than at lower speeds. This statement must not be taken absolutely, since the curves for certain types of propellers cross each other, and the entire question is a very complex one.

The efficiencies of the small models were also lower than those of the large propellers, a fact which may be attributed to the circumstance that the ratio $\frac{R_x}{R_y}$ of the components of the reaction of the air upon the blade diminishes as the velocity increases, a fact already observed in the investigation of the Nieuport aeroplane.

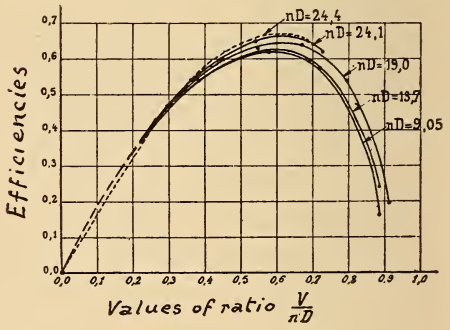
The departure from the law of the square of the velocity, however, is not the only cause of the perturbations. The blade itself, under the influence of centrifugal force, is subjected to deforming forces which doubtless have very perceptible effects. To this must also be added the deformations caused by the pressure of the air, the effects of which are necessarily very difficult to determine.

These perturbations, however, so far from rendering the experiments upon models deceptive or useless, only serve to indicate their utility.



PROPELLER POWER CURVES

If, for example, the trials are so arranged that the relative velocities of the blade and the air are identical, not only in direction but in intensity, for both the model and for the full-sized propeller—that is, for example, if we make the model one-third size driven at 3,000 revolutions, and the full-sized propeller driven at 1,000 revolutions, we find: (1) that if the relative velocities are the same, the relations to the law of the square of the velocity will be the same, and that the pressure of the air will be practically the same upon two corresponding portions of the two propellers; (2) that the efforts of cen-



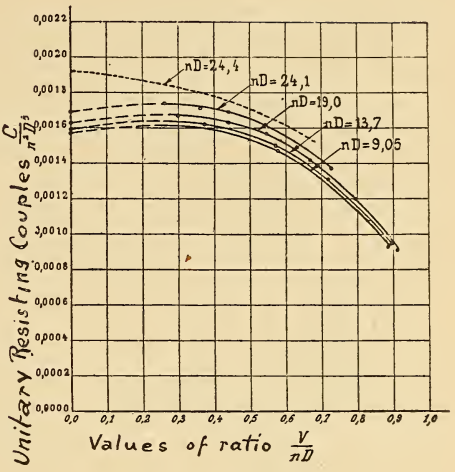
PROPELLER EFFICIENCY CURVES

trifugal force will be the same at two homologous points of the two propellers, so that if they are made of the same material the elongation per unit will be the same for two homologous elements. That is, the deformations of the propeller and the model will be geometrically proportional, so that even under deformation the two propellers will continue to be geometrically similar. This conclusion has also been arrived at independently by Commandant Dorand.

It follows, therefore, that the curves $\frac{F}{n^2D^4}$, etc., as functions of $\frac{V}{nD}$ obtained from a model, may be applied to a full-sized propeller, if the relative velocities of the blade and the air are the same.

In order that this may be verified, M. Drzewiecki has made a full-sized propeller and a model of one-third size, of such proportions that they could be tested with the same velocities of blade and air. The propeller was 2.715 metres in diameter and operated at 540 revolutions per minute. The model was one-third of this diameter, or 0.905 metre, and given three times the speed, or 1,600 revolutions. The value of nD was, therefore,: $2.715 \times \frac{540}{60} = 24.4$ for the large propeler, and $0.905 \times \frac{1{,}600}{60} = 24.1$ for the small model. These values, multiplied by π, give the circumferential velocities in metres per second as 77 and 76 metres. In the other tests the number of revolutions of the model were 600, 942 and 1,260 per minute.

The results of these trials are shown in the diagrams, which also serve to illustrate the author's method of representing his investigations. We have given for each curve the corresponding value for nD in such a manner that the diagrams may be applied, with all their indications, to all propellers of different diameters,



PROPELLER TORSION CURVES

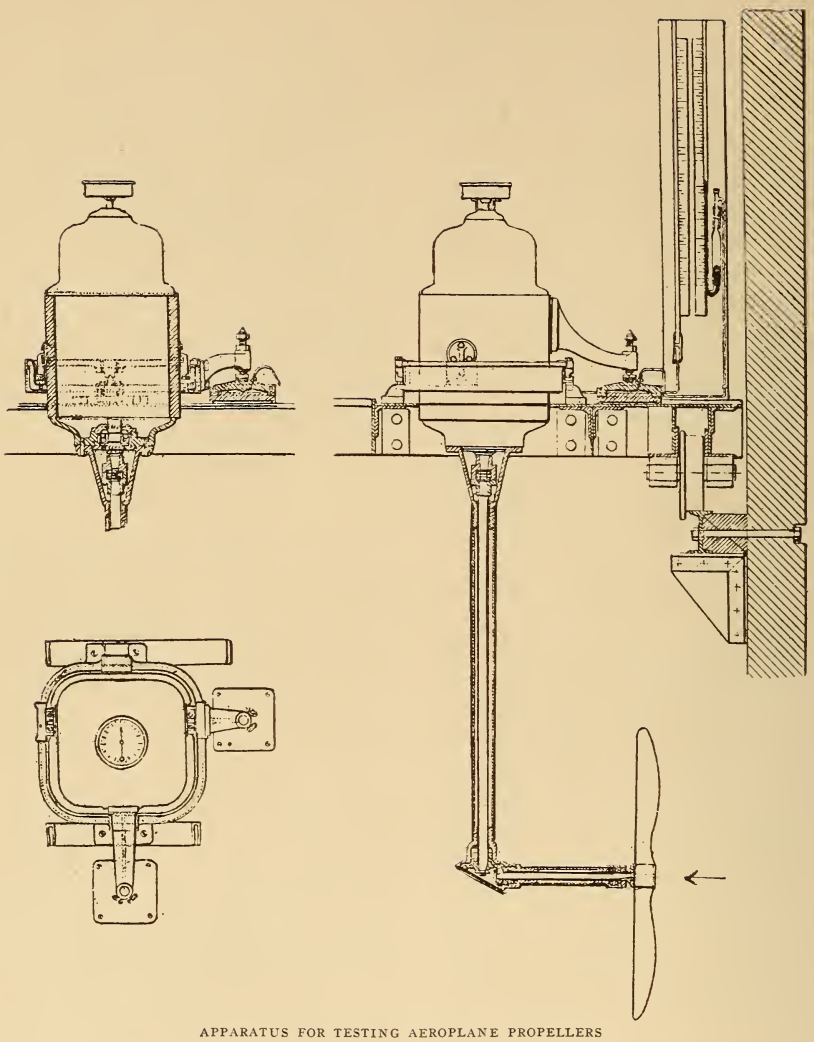
provided they are geometrically similar.

We see from these diagrams, in those portions corresponding to good efficiencies—that is, under conditions of normal operation—that one and the same value of $\frac{V}{nD}$ corresponds to values sensibly different for $\frac{F}{n^2D^4}$, $\frac{C}{n^2D^5}$, etc., thus failing to agree with the formulas which we have given above. Since, in our trials the relative velocity of the air reached 80 metres per second for 1,600 revolutions per minute, and as in practice velocities approaching 150 metres per second are encountered, the departure from the law of the square will probably account for these differences.

These diagrams also show that the curves obtained from the model differ very little from those of the large propeller when the products nD are the same—that is, when the relative velocities are the same.

This confirmation of our views permits us to conclude that:

1. The resistances of propellers cannot be regarded as being exactly proportional to the squares of the relative velocities. The diagrams



APPARATUS FOR TESTING AEROPLANE PROPELLERS

representing $\frac{F}{n^2D^4}$, etc, as functions of $\frac{V}{nD}$ generally show several curves; but, in spite of this, we believe that they will be found useful. They replace a number of separate diagrams, the curves often approximate closely to each other, and they show the perturbations due to the two causes which we have indicated.

2. The study of a model of a propeller enables the performance of the propeller itself to be deduced. The only condition to be observed in testing the model is to maintain the same relative velocity, in magnitude and direction, as is to be used for the full-sized propeller, which means that the velocity of the wind must be the same in both cases and that the velocities of rotation must be inversely as the diameters of the two propellers.

For this reason the author, in his new laboratory, has provided for air velocities reaching 144 kilometres (about 90 miles), besides a new ap-

paratus permitting the propellers to be tested at speeds as high as 4,000 revolutions.

This apparatus, which is shown in the illustration, is based upon a different principle from the previous one. Since the power absorbed by the propeller will reach 12 to 15 horsepower, instead of 2 horse-power, the motor would be too large to be placed directly behind the propeller. The shaft is, therefore, arranged with mitre gearing in such a manner that the motor may be placed upon the frame of the aerodynamic balance. The entire apparatus is suspended upon a universal joint, similar to the gimbals of a compass, maintaining an invariable relation to the pressure points upon the diaphragms of the dynamometer. One of these pressure points opposes the effort of the propeller to displacement in a direction parallel to the wind, and the other opposes its displacement in a perpendicular direction. The one, therefore, opposes the thrust of the propeller and the other the resisting couple, so that the pressures upon the diaphragms, transmitted to the pressure gauges, are proportional, one to the thrust and the other to the couple of the propeller. The high rotative speeds at which this apparatus is to be used demand very accurate balancing and involve precautions against breakage of the propellers, and the practical problems in the tests will be difficult and possibly dangerous, but it is hoped that valuable results will follow.

EDITORIAL NOTE

The inception and continuation of experiments such as have been undertaken by M. Eiffel are noteworthy as being a definite attempt by an eminent engineer to place the data of aviation in a position similar to the material available in other departments of applied science. It is well known that the late Professor Langley undertook to make various determinations of the fundamental data relating to the behaviour of moving surfaces through the air, and his work has been well supplemented by his successors, but much of the information thus obtained has been in private hands and not generally available for use in design and construction of machines.

The art of aviation, or rather the science of aeroplane design and construction, is beginning to pass from the empirical to the rational stage, and there is every reason to believe that this is the principal thing needed to place the building of machines for aerial navigation in a much better position, commercially concerned.

The first feeling of satisfaction at being able to fly at all was followed by a rush to build machines of all kinds and to attempt many things which better information would have discouraged. It is yet too soon to consider that the art of designing flying machines is in a settled state, or that it can be acquired in a manner similar to other departments of industrial effort. When, however, such investigations as those of M. Eiffel are carried on in a thorough and scientific manner, and the results are presented, through the medium of a professional organization of the highest standing, to its members and to the engineering world, the time will soon be reached when aeroplane construction will be placed in a similar position to that which has already been attained by the automobile.

Any examination of the various automobile vehicles which were in vogue a decade ago, in comparison with the scientifically designed machines of to-day, will indicate what may be anticipated by the application of similar methods to the newer industry.

In his new laboratory at Auteuil,

M. Eiffel has installed apparatus for experimental investigations, not only upon propellers of large size, operated at high velocities, but also has arranged for the quantitative study of the forces acting upon complete machines. This includes the investigation of model aeroplanes, placed in the path of air currents of high velocities in such a manner as to enable the behaviour of various arrangements of planes to be studied accurately, so that it will be unnecessary for actual machines to be tried out in the air, at large expense and possible risk, until models have been tested.

The immense advantages which have accrued to naval architecture by the use of the testing tank, and the construction of models of hulls of various forms, will enable some idea to be obtained of the relation of the investigations of M. Eiffel to the art of aviation.

When to such researches there are added scientific trials of motors and propellers, it will be found that much of the uncertainty now surrounding the behaviour of a newly designed machine will pass away, and the work become as thoroughly an engineering problem as the design of a cup defender or a locomotive.

M. Eiffel has announced his intention of continuing this important work and of presenting the data and results to the Society of Civil Engineers of France, of which he is past president, and it will be a satisfaction to place this work before the readers of this magazine as it becomes available.

Such a task, however, should not be left in the hands of a single individual, or even in the scope of a single professional society, and it would seem altogether desirable that the organizations already in existence might do well to establish suitable testing laboratories, both for the investigation of special problems and also for checking and confirming the results already obtained by the efforts of the eminent engineer who has started the work.

THE RAILWAYS OF SOUTH AMERICA

III.—NORMAL GAUGE RAILWAYS OF ARGENTINA AND PARAGUAY

(Concluded from October issue)

By R. Renewal

ARGENTINE NORTH EASTERN RAILWAY

The "Argentine North Eastern Railway" is almost entirely in the Province of Corrientes. Its main line connects Salto with Corrientes, thus opening up through connection from Buenos Aires. Subsequently, however, a new objective has led to the construction of the Monte Caseros & Posadas line, opening up connection with the Republic of Paraguay. Originally separate undertakings, they were merged together in 1906.

The Rio Uruguay, one of the large streams forming the River Plate, is navigable all the way up to Salto. Then there is a gap from here to Ceibo, the port of Monte Caseros, whence navigation is possible again to San Tomé. It is thus a fine, continuous line from Buenos Aires up to San Tomé, except between Salto and Ceibo. That is why the obsolete "East Argentine" Railway was formed to construct and work a trans-rapids line, bridging this gap on the Argentine bank.

This line, which was constructed by Government on the 11-10-1864, was to be broad gauge. It was reduced, sensibly, to the 4-foot 8½-inch gauge, the same as that of the Central Entrerio Railway, on the 20-9-1869, an extension to Hervidero being agreed to at the same time. The transfer which the original concessionaires made to the East Argentine Railway was sanctioned on the 10-9-1871. It was opened to traffic between Concordia and Monte Caseros in 1875. The Monte Caseros & Ceibo branch, 3 miles long, conceded on the 15-10-1878, was opened in 1880.

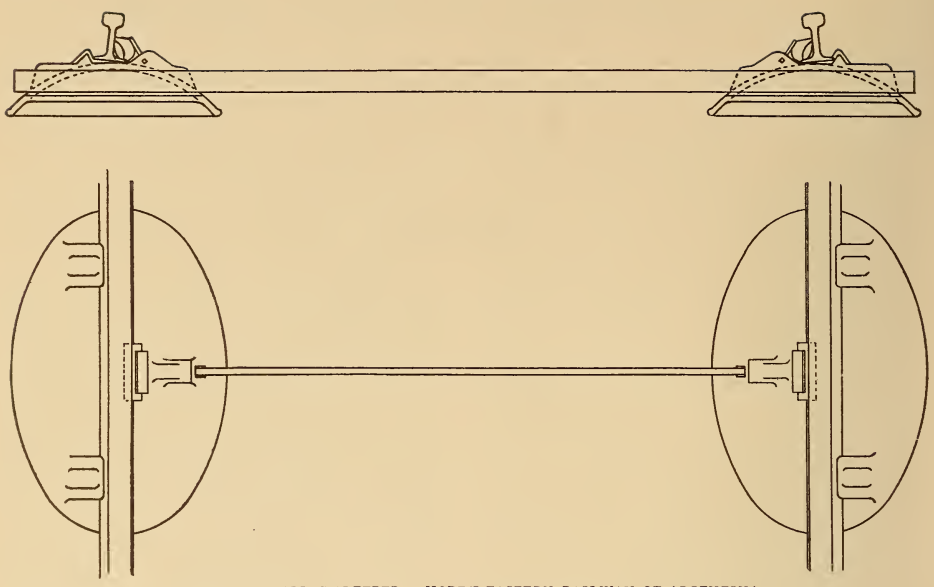
Though the original concession granted the line up to Mercédès and a later decree (5-1-1900) granted a branch to Chajari Sauce, no further construction work was gone in for, and the East Argentine stagnated until it was merged into the "North Eastern Railway" system on the 1-11-1907.

Government having conceded the line up to Mercédès, was wishful to link up Corrientes, the capital of the Province, with this system, so the Corrientes & Mercédès line was one of "five national roads" decreed on the 5-11-1873 (law 583).

The East Argentine, not having proceeded with the building of its line beyond Monte Caseros, the law (1891) of the 30-10-1886 incorporated this section with the line from Monte Caseros to Corrientes, and the line from Monte Caseros to Posadas, on the Upper Rio Parana, whose construction and subsequent exploitation Government contracted with J. E. Clark and subsidized with $3,500,000 (£694,444) in 4 per cent. External Bonds, with ½ per cent. sinking fund.

He started work at both extremities of the Monte Caseros and Corrientes line, that town being situated on the Rio Parana, which is navigable. It was opened to traffic from Monte Caseros to Curuzu-Cuatia, 40 miles, on the 1-7-1890, and on to Mercédès, 47 miles, on the 15-3-1891, the same day as the section from Corrientes to Saladas, 61 miles long.

The contract stipulated that, should dividends exceed 12 per cent., Government might intervene in the



LIVESEY METALLIC SLEEPER. NORTH-EASTERN RAILWAY OF ARGENTINA

tariffs, in exchange of a 6 per cent. guarantee on 31,000 pesos gold per kilometer during 20 years. Any sums above 16 per cent. were to be reimbursed to Government.

Work was also started on the Posadas line, when, on the 22-5-1888, the concession was handed over to the Argentine North Eastern Railway.

This company built the intervening section of the Corrientes line between Mercédès and Saladas, 85 miles long, which was opened to traffic on the 10-7-1898.

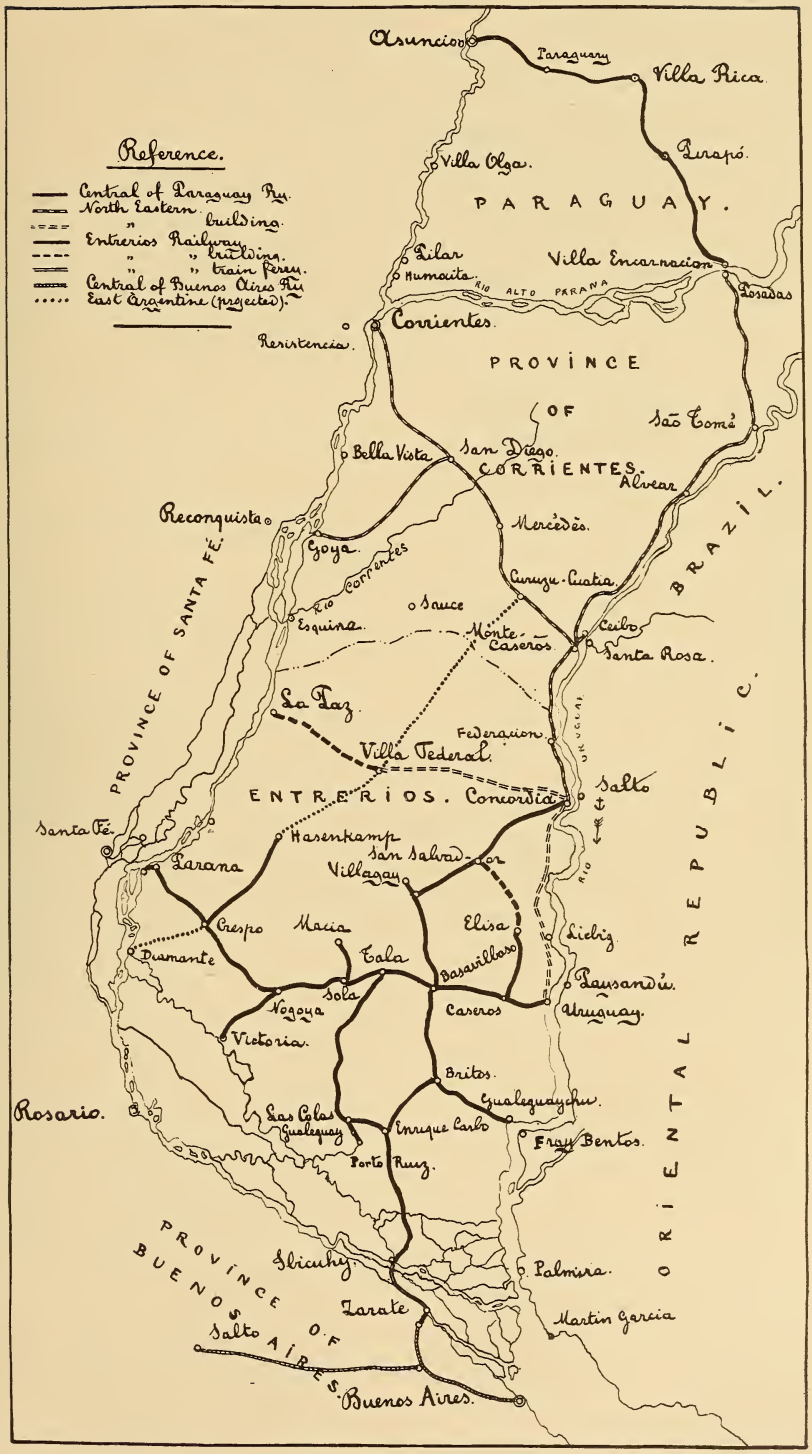
The Posadas line starts from the 6th mile beyond Monte Caseros and follows at some short distance the right bank of the Rio Uruguay all the way to San Tomé, on which section that river is navigable and there is a steamer service; but between Uruguayana, opposite Libres, and San Borja, opposite San Tomé, the Brazil Great Southern Railway, another British concern, starting from Cuareim, opposite Monte Caseros, runs up the left bank as far as San Borja.

The North Eastern's line here strikes due north, reaching the River Upper Parana at Posadas. The line was opened at Libres on the 1-2-1894 to San Tomé on the 3-2-1901, and to Posadas on the 1-5-1911. The river, which forms the frontier between Argentine and Paraguay, will shortly be crossed to Villa Encarnacion on train ferry steamers similar to those of the Entrerios Railway on the Lower Parana River. The first of these—*La Rogre Saenz Penna*—is 200 feet long, 35 feet wide, and carries six Pullmans, three on each of its two lines of rails. Its speed, when fully loaded to a draft of 4½ feet, is 10 knots against the current.

A 50-mile branch from San Diego to Goya was opened in 1910.

Goya is a port on the Rio Parana River opposite the town of Reconquista. Almost any branch running from inland to either of the two navigable rivers that border it is bound to become rapidly a good traffic carrier.

The concession of the Goya mole is for 30 years, when it reverts to Government. Government may expropriate it any time upon payment of valuation plus 20 per cent.



MAP OF THE NORMAL GAUGE RAILWAYS OF ARGENTINA

Cargo traveling over the railway is free of license taxation.

Further Extensions.—The River Uruguay is not always navigable for deep draft steamers up to Concordia, whereas it is at all times up to Concepcion del Uruguay, lower downstream. The North Eastern Railway obtained in 1909 a concession between these two towns along the river bank (52 miles) paralleling the line of the Midland Railway of Uruguay, on the other bank. Harbour works will be undertaken at the same time, so as to allow the large ocean-going steamers to unload directly in Concepcion on to the cars of the North Eastern Railway. The line runs near Colon and through the Liebig Company's important colony. It is an encroachment into the Entrerios territory which does not tend to foster closer relationship between the two railways.

Another line was conceded the same year from Concordia, on the Uruguay River, inland to Villa Federal, a distance of 37 miles. It carries a subvention of $4,681 per kilometer. It will most likely be extended to La Paz, on the Rio Parana, which is navigable far up-stream, whereas Concordia is the upper extremity of navigation on the Rio Uruguay. This line is, therefore, quite analogous to the Caxias & Terezina Railway in Brazil.

The company's system is made up of the following sections:

	Miles.
Concordia to Monte Caseros	96
Monte Caseros to Ceibo	3
Monte Caseros to Corrientes	233
Kilometer 9 to Posadas	277
San' Diego to Goyaz	
Corrientes to the Mole	1
Libres to the Mole	2
Porto Alvear branch	2
Santo Tomé to the Mole	2
	666

All these lines have been easy to build, and run through a very even country. The steepest gradients are but 1 in 77 on the Central of Buenos Aires Railway, 1 in 83 on the Entrerios Railway, 1 in 66 on the Argentine North Eastern Railway.

The radius of the curves is proportionally shorter, as it is on the broad gauge lines as well. The Entrerios Railway has some of 656 feet, the North Eastern of 820 feet and the Central Argentine 1,017 feet radius.

The lines are remarkably straight, as compared with Brazilian roads, there only being some 15 per cent. of curves altogether, whereas the Brazilian railways frequently put up with over half the total length.

The rails are steel, and weigh 70, 50 and 30 pounds per yard on the Central of Buenos Aires Railway; 75, 65 and 47 pounds per yard on the Entrerios Railway, and 64 and 55 pounds per yard on the Argentine North Eastern Railway.

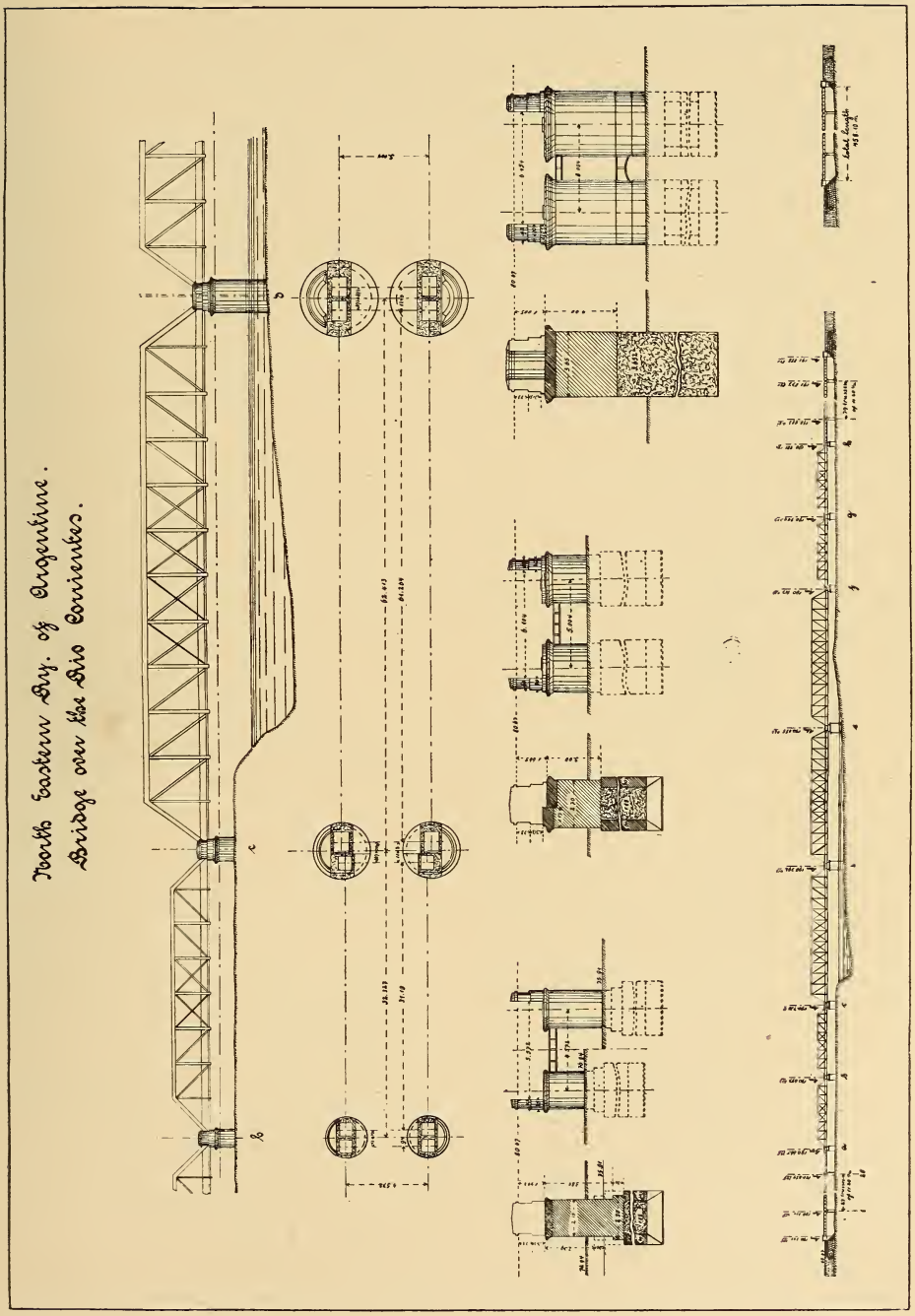
They are laid mostly on hardwood, quebracho sleepers (78.62 per cent. of the total for the three systems), a small portion of the Entrerios (152 miles) being laid on steel sleepers and 111 miles of the North Eastern on Livesey pots.

This interesting system is still to be found on quite a number of Argentine roads, aggregating (end of 1909) 2,112 miles, or no less than 13.72 per cent. of the entire system, whereas but 12.91 per cent. are laid on steel sleepers.

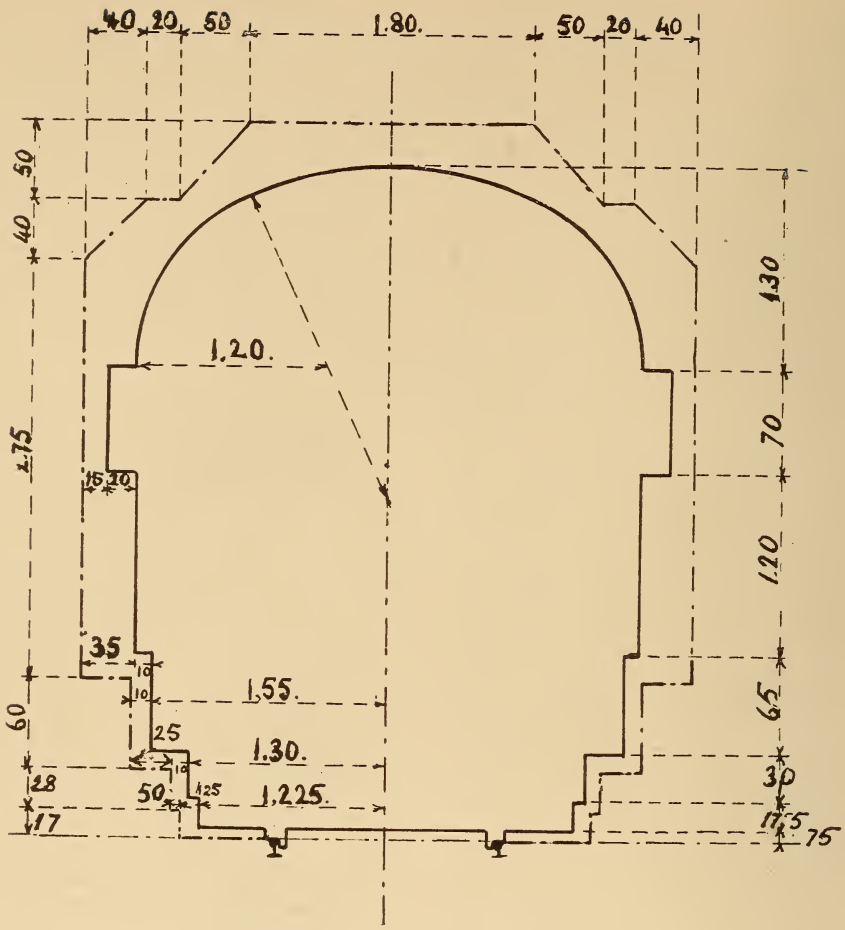
Wood is also used as fuel on some of the locomotives, as it is cheaper than coal, but not very much so. This depends, of course, on the number of heat units of similar quantities. Experiments have been undertaken by a number of Argentine railways so as to ascertain the exact proportions, and the results they have arrived at being particularly useful are quoted hereunder.

Quebracho wood has been tested on a large scale on the Santa Fé Railways, who consider its heating power to be 34 per cent. of that of coal (in weight).

Algorrobo wood, used on the Cordoba & Rosario Railway, is 52 per cent., the Andino Railway quoting 87 per cent, which seems excessive, and the Entrerios 36, which seems low.



A TYPICAL RAILWAY BRIDGE OF ARGENTINA. BRIDGE OVER THE RIO CORRIENTES



LOADING GAUGE FOR THE ARGENTINA RAILWAYS

The North Eastern uses nandubay, whose equivalence is 44 per cent.

As to cost, the North Eastern Railway considers that, under equal weight, wood costs but 31 per cent. of what coal does, whilst the Entre-rios gives 49 per cent. Considering the heat value as 44 per cent. and 36 per cent. in the two cases, the proposition is reversed on the roads, which is due to the former running through some fine forest land, which the latter does not.

It should also be borne in mind that the freight to Buenos Aires is exceptionally low, and that it can reach all these railways by water, up the Rios Uruguay or Parana, should it suit them.

NORMAL GAUGE RAILWAY OF PARAGUAY

Since the disastrous war that killed off such a large proportion of the male population of Paraguay, and reduced its territory to its present relatively small area, Paraguay has been cut off from the neighbouring Republics, and, until recently, had no direct communication with them.

Shortly, however, there will be three lines of communication into the country:

Up the Parana River to Corrientes, where steamers can ply up either branch to Asuncion, the capital, or to Villa Encarnacion. Most of this traffic is in the hands of the Mihanovitch Navigation Company.

The second ingress is by rail from Buenos Aires over the Entrerios Railway to Concordia, and the North Eastern to Posadas, and thence crossing the Upper Rio Parana on the train ferry shortly to be established from Villa Encarnacion to Asuncion by rail over the recently completed Central of Paraguay Railway.

The third line is the Brazilian penetration line: from San Francisco, on the coast, to Porto do Unuiao and the mouth of the Iguassu River over the San Paulo & Rio Grande Railway, and across the Upper Rio Parana on a bridge, reaching Ascencion by the Trans-Paraguayan Railway, which is about to be built.

A good deal of international competition is bound to take place, especially as this latter line is one of the "Brazil Railway's" subsidiary companies, and will be a source of North American penetration into the Republic. The fear of the Brazil Railway buying up the shares of the Central Paraguay is already creating no little unrest in Buenos Aires.

CENTRAL OF PARAGUAY RAILWAY

This line, 240 miles long, was begun as early as 1859, and has been concluded in 1911 only, an average of less than five miles a year.

It was Don Carlos Antonio Lopez's Government that devised, in June, 1859, to construct a line from Asuncion, on the Rio Parna, to Villa Rica, an important inland town. Work was started immediately, and the first section, as far as the Rio Paraguari (45 miles), was built. Surveys of the second section had been started when the disastrous war that ruined the country broke out, and all work was stopped until 1886. The original concession was canceled, and a syndicate formed by Luis Putri took up the work, under the direction of Giles Regnault, a French engineer.

But progress was slow, so a law was passed on the 22-9-1887 which allowed Government to sell the railway, on condition it should be extended. In May, 1889, the Central Paraguay Railway took over the road under a contract, which is still binding.

The price paid was gold pesos, 2,100,000, half in cash and half in preference 6 per cent. shares. The line was to be finished to Encarnacion by 1894, except in case of *force majeure*. The company might build any branches, but these had no Government guarantee of interest. This guarantee of 6 per cent. applied to the whole of the main line, but for twenty years only, the guaranteed capital being computed at gold $30,000 per kilometer on the extension and at the sale price for the first portion. This guarantee was calculated upon the basis of a 65 per cent. working percentage.

In exchange, the company reimburses the State with the monthly net profits. When these net profits exceed 6 per cent. they serve to constitute a reserve fund, in whose formation Government intervenes until it shall have reached $500,000 gold, above which reimbursement to Government takes place. The Government may intervene in the fixing of rates and tariffs during the guarantee period, and fix them, without consulting the company, should net profits exceed 12 per cent.

The concession is a perpetual one. The company has the usual privileges: expropriation, exemption from duty and taxation, the right to use any timber or stone found on national land, exemption from military service for employees, etc.

The right to renounce Government guarantee upon repayment of all sums advanced by Government was also granted (law of the 31-7-1890).

These clauses have formed the basis of the railway act passed later and applicable to all Paraguayan railways.

The financial crisis that hit the River Plate, Brazil and Paraguay again interrupted construction at the

156th mile, some 62 beyond Villa Rica, on the banks of the Rio Pirapo, with but 84 more to build, and this time it looked as if the interruption were going to be final.

It is owing to extraneous causes that such has not been the case, the opening of the new line from Buenos Aires to Entrerios and the Corrientes Province having brought the Argentine companies to look beyond for more traffic.

The contract for linking up the lines of the North Eastern Railway of Argentine and the Central Railway of Paraguay was signed on July 23, 1909, and ratified the following year.

The North Eastern Railway undertook to have the gauge of the Central Paraguay reduced from 5 feet 3 inches (1.676 metre) to 4 feet 8½ inches, so as to allow through traffic and to run ferry steamers across the Rio Parana from Posadas to Villa Encarnacion.

It also agreed to purchase all the broad gauge rolling stock of the Central Paraguay for the Argentine Government, who will use it on the new broad gauge Patagonia Railway they are constructing.

Government pays the North Eastern, for the conversion of the Central of Paraguay's gauge, purchase of rolling stock, etc., $2,167,200 gold (Argentine currency) independently of the sum of $252,000 (£52,000) for the train ferries across the Rio Parana. This covers the building of the last Paraguayan section of 126 kilometers (subsidized by the Argentine Government at $5,000 per kilometer) and conversion of the original 246 kilometers at the rate of $1,250 per kilometer.

In exchange of this subsidy the Central of Paraguay Railway will hand over to the Argentine Government 1,220,000 in ordinary shares, which will give it the right to nominate a director in London and one in Buenos Aires. Should the Argentine Government wish to sell these shares they should give preference to the Central of Paraguay Railway.

Work has been started once again, and the line opened to Encarnacion in 1911. It has been easy to build, the maximum gradients reaching but 1 in 75 and sharpest curves radius 2,264 feet radius (600 meters). Many of the bridges were originally built of timber, either lapacho (weighing 66 pounds per cubic foot), the "ipé" of Brazil, usundel, or curupu, which are excellent. The sleepers are mostly of quebraho (84 pounds), found here in large quantities. The rails are of the American profile.

Two branches have been recently conceded: from Villa Rica southwards and from Villa Rica due east to the River Parana, opposite the mouth of the Iguassu, where the Brazil-Paraguay meter gauge line of the San Paulo & Rio Grande Railway, now under construction, will terminate.

This is the last (and most recent) of normal gauge railways on the east coast. They occupy a definite region, which is physically cut off, anyhow, from the remainder of the railways of the continent, or, at least, from most of them, minimizing the inconvenience of a separate gauge.

The attraction exercised by Montevideo, in Uruguay, and by Buenos Aires over the Argentine and Paraguayan portion, has tended, together with the course of the great rivers, to render cross connection hardly necessary; and so long as these Republics continue to develop radially, the capital or the river ports alone need be connected with the interior. There is little interchange of traffic between the Republics of Uruguay and Argentine, whose productions are similar, which, joined to the fact that the frontier follows the Rio Uruguay, navigable a good way up, will render the building of a bridge connecting the Entrerios and Central of Uruguay systems an event of the remote future.

THE UTILIZATION OF PEAT FUEL

CANADIAN DEPARTMENT OF MINES

IT is an interesting indication of the rational development of applied science that, instead of attempting to select only those materials which are adapted to older methods of operation, the engineer is beginning to realize that the true road to progress is to devise methods which shall place available materials in the position of highly efficient use. At one time anthracite coal was regarded as worthless, because it could not be effectively burned by methods which had been used for bituminous coal, so that large tracts of anthracite coal lands were held at small value. It is entirely possible that the development of suitable methods of use will bring other fuels into the front rank of service, simply by the provision of apparatus and methods adapted for the purpose. The work which is being done by the Department of Mines of Canada, and discussed in a recent report prepared by Mr. B. F. Haanel upon the utilization of peat as fuel, is an excellent indication of the possibilities of applied science to such practical commercial problems.

The principal difference between such a fuel as peat and the harder varieties of natural carboniferous fuels lies in the great proportion of moisture present, the amount of water reaching from 25 to 30 per cent. of the weight of the material. The presence of so large a proportion of moisture renders it impracticable to use peat in the raw state in ordinary furnaces designed for the combustion of coal, and hence various attempts have been made to remove the moisture and leave only the fixed carbon, volatile matter and ash, the latter forming usually less than 10 per cent. of the material. In some portions of Europe where peat is used as a household fuel, the pieces of turf are simply air-dried, being impaled upon sticks and exposed to the action of the sun and wind. For power purposes on any considerable scale, however, the cost of removing the moisture has been a formidable element to be overcome, and thus attention has been turned toward what seems to be the true and logical method of utilizing this plentiful supply of fuel—that is, the manufacture of producer gas for use in the internal-combustion engine.

It is well known that when a gas producer is operated with anthracite coal or with coke a certain proportion of steam is introduced, this serving to prevent overheating during the oxidation of the fuel to carbon monoxide, and also rendering much of the sensible heat available for the production of power by the decomposition of the water and the addition of a corresponding amount of hydrogen to the gaseous mixture.

This fact at once suggests that if the fuel itself contains the desired moisture no steam need be added, and that if a suitable producer could be devised it would be practicable to use peat as fuel without any preliminary operation of drying. This is the lead which has been followed in the Canadian investigations, and the success which has been obtained seems to justify the work and to demonstrate the fact that an abundant and economical source of power exists in peat deposits.

At the fuel testing station at Ot-

tawa the experiments were made with a suction gas power equipment, the gas engine drawing the air through the producer, and through the purifying apparatus, and using it for the production of power as rapidly as made. The producer originally used was of a type made by Messrs. Körting for use with peat, and the purifying apparatus devised to remove the tar from the gas by scrubbing; and the success attained with this apparatus led to its improvement, in the light of the experience gained during the tests, until the practicability of utilizing peat fuel for power generation was commercially demonstrated.

The general arrangement of a typical equipment is shown in the illustration, this serving to show broadly the various parts rather than the details of construction. The suction stroke of the gas engine maintains a flow through the producer and scrubbers, the tar being largely removed in the wet coke scrubber, the heavier tarry matter being removed by woody fibre in the dry scrubber, both coke and woody fibre requiring to be cleansed every two or three months.

The particular design of producer used with peat fuel in the original tests at Ottawa is shown in the illustration.

The producer consists of a rectangular steel shell, having the following outside dimensions: 2 feet 9 inches by 5 feet 2 inches, in horizontal section, and 15 feet high, from floor level to top of charging hoppers. For cleaning fires and removing ashes, twelve doors are provided: four on each side and four on the back.

The producer consists of two combustion zones: *F-F* at the top and *M* at the bottom. *F-F* represents inclined grate bars; *D-D* doors for poking and cleaning the fires resting on the grates *F-F*. The ashes resulting from the combustion of the fuel on these grates drop into the chambers *Z-Z*, and are removed through the doors *E-E*. The gases evolved at this zone are drawn off through the chamber *B*. The dust and tar which are caught in this chamber are removed through a door on the back of the producer. *A-A* represents charging hoppers.

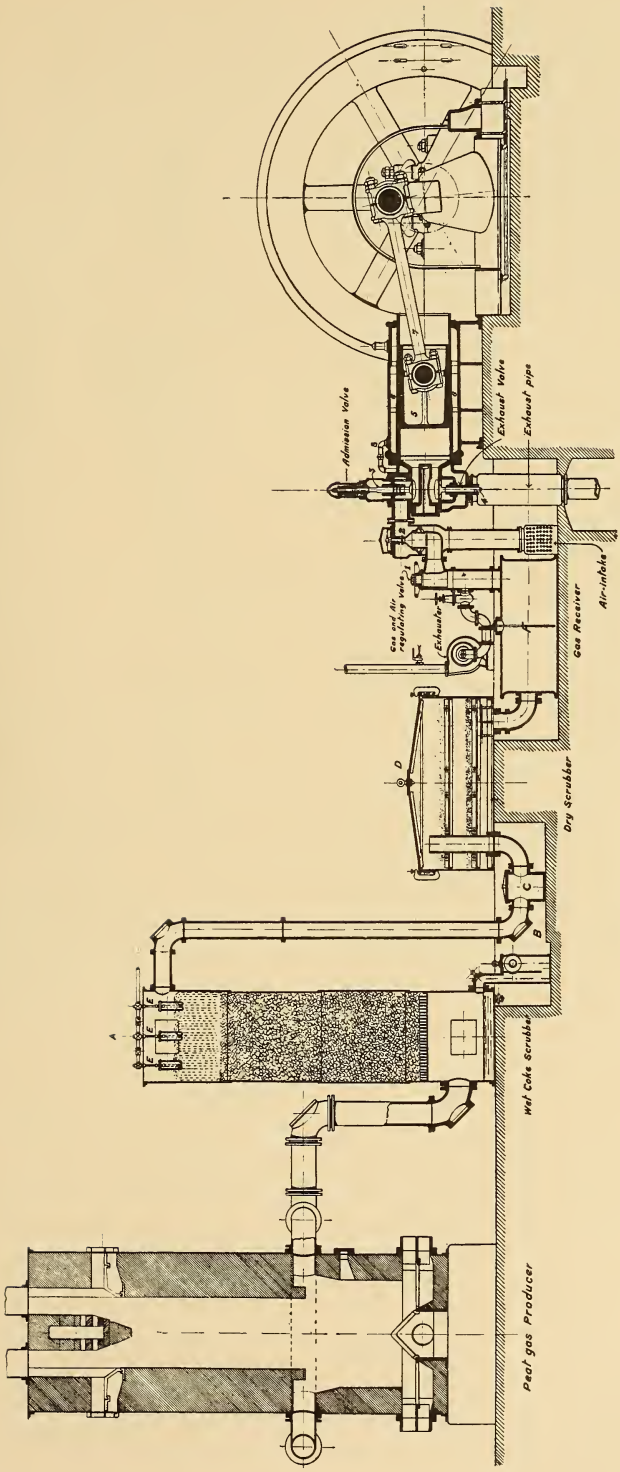
M represents the grate bars of the lower zone, and *I-I* the doors through which the fires of the lower zone are poked and cleaned. The fire above the grates of the lower zone is poked through the doors *Q-Q*. The ashes resulting from the complete combustion of the fuel in this zone fall through the grate bars into the chambers *O-O* and are removed through the doors *J-J*.

The products of the combustion taking place in the upper zone are drawn off through chamber *B*, through the pipe *C* and vertical pipe *V*, shown in Fig. 4, to chamber *K*, when they pass finally through the fuel of the lower zone to the two gas off-takes *H-H*.

S, at the top of vertical pipe *V*, is a damper, which is opened to allow the gases resulting from the combustion of the peat to pass into the atmosphere—when the producer is standing idle. The damper *T* is closed while the producer is standing idle, but it is opened and the damper *S* closed when the producer is in operation. These two dampers are provided with cover plates, which can be readily removed when it is necessary to remove from the damper chambers any material which has collected therein. The vertical gas pipe *V* is cooled by means of cold water continually circulating in the jacket *U*. The cooling water enters at the bottom of this jacket and overflows at the top. *W* is a water seal, which covers the open bottom of the vertical pipe *V*.

The ashes which fall through the grate bars *M* into the gas chamber *K* are removed through door *R*.

The off-takes *H-H* are provided with caps held firmly in place by clamps, which may be removed for the purpose of inspecting the interior of the producer at this point, or for



GENERAL ARRANGEMENT OF GAS PRODUCER AND ENGINE PLANT FOR PEAT FUEL

the purpose of removing any dust or tarry matter which may collect in the gas chambers.

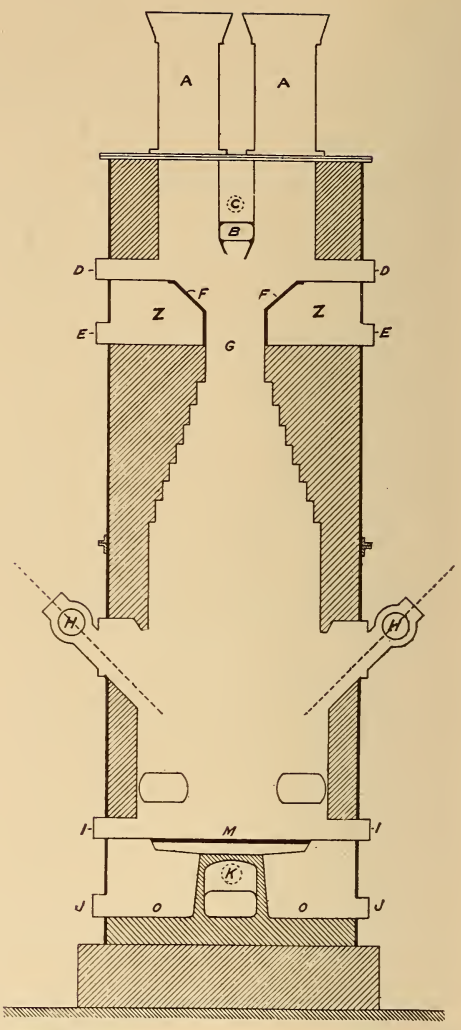
The two ends of the pipes connecting the producer to the cleaning system are provided with caps 1, 2, 3 and 4, respectively, which can be easily removed, when necessary, for the purpose of clearing them of any matter which may adhere to the walls of these pipes.

For the purpose of regulating the amount of air entering the producer at the top and bottom zones, two adjustable air openings—not shown in the figures—are provided on each of the doors *E-E* and *J-J*.

The peat used in the tests at Ottawa varied somewhat according to the locality from which it was procured, but contained, on an average, from 25 to 30 per cent. of moisture, while the solid portion, after drying, gave, upon analysis, about 25 per cent. of fixed carbon and 70 per cent. of volatile matter, and a calorific value of 8,650 British thermal units per pound. The first trials, however, were made with a peat which had been stored for more than a year, and was in a dry condition, not representing the condition of the fuel as it would be generally used, and attempts to introduce steam in a producer not designed to be so operated were not altogether satisfactory. Nevertheless, the results were so encouraging that plans were made to continue the work, with such modifications in the apparatus as the trials indicated.

Thus, under the above conditions, in an engine developing about 50 horse-power and operating at a speed of 200 revolutions per minute, the fuel consumption, in a run of twelve hours' duration, was 2.45 pounds of peat per horse-power per hour.

The dry condition and large amount of fusible ash in the peat, coupled with the high working temperature which could not be controlled, caused the formation of clinkers, and interfered, to some extent, with the regular operation of



SECTION OF KORTING GAS PRODUCER FOR PEAT FUEL

the producer. The trouble most noticeable was the irregular feeding of the fuel into the lower zone. This was caused by clinkers adhering to the walls above the doors provided for poking and resulted in scaffolding. The large hollow spaces thus formed in the lower zone caused irregularity in the composition of the gas and the formation of some tar. The tar was due to the feeding into the lower zone of uncoked peat; for, when the clinkers broke away—on account of the weight of fuel resting on them, or when broken away by

poking—large quantities of green or partially coked peat dropped into this zone from the upper portions of the producer instead of passing slowly and regularly down through the upper zone. The tar carried over through the cleaning system only gave trouble at the admission valve, which showed signs of sticking several times during the trial. This trouble was, however, easily overcome by dropping a little gasoline around the spindle of the valve. The irregularity in the composition of the gas was easily taken care of by the air and gas regulating valve, and at no time during the trial was this irregularity serious enough to necessitate a reduction of the load carried on the engine.

Although no attempts have been made, so far as known, to use any fluxing method to render the ash fusible enough to be removed by tapping in producers in which peat is used as fuel, the excellent results which have followed such a method in the tests of the United States Bureau of Mines would indicate that the use of limestone or similar flux would be worthy of trial in connection with the removal of clinker.

A later series of tests, using peat from the government plant at Alfred, is of interest, because the fuel was more nearly in the natural condition, so far as the content of moisture is considered.

After the completion of the chemical laboratory, tests were begun with the peat manufactured at the Government peat plant at Alfred. Before beginning these tests considerable time was spent in ascertaining the size to which the peat should be crushed in order to obtain the best results in the producer. It was found that peat containing 30 per cent. of moisture should be crushed to about the size of a hen's egg, while for peat containing less moisture larger sizes may be used, although the smaller sizes offer no difficulties to the operation of the producer—regardless of the moisture content.

The crushing is accomplished by a modified stone pulverizer. This, in its original form, consisted of two spiral corrugated steel rolls of about 6 inches diameter by 2 feet long, driven, by hand, through a system of cog wheels. The maximum clearance that could be obtained was only one inch, which crushed the peat too small. Moreover, the corrugations were only about $\frac{1}{8}$ inch deep, so that the rolls failed to grip the peat. The original rolls—which could not be adapted to this class of crushing—were replaced by two cast-iron rolls provided with spikes about $1\frac{1}{2}$ inches long. These proved to be both satisfactory and inexpensive. The crusher is driven by a 5 horse-power direct-current motor, which happened to be on hand. The power furnished by this motor is altogether too high, a 2 horse-power motor being sufficiently powerful to do the work. The considerable amount of fines which resulted from the crushing caused no trouble whatever in the operation of the producer. This was conclusively proved by the experiments carried out with screened peat, and also with the peat mixed with fines just as it left the crusher.

During this trial the producer and engine were operated continuously at full load for a period of thirty hours, for the purpose of determining the fuel consumption per brake-horse-power-hour, the uniformity of the gas, the water consumption for cooling purposes, and the behaviour of the plant in general during a period of that duration.

Previous to this trial the producer had been standing idle for some time; consequently, was comparatively cold when the trial commenced. No pyrometer measurements were made of gas in the off-takes, hence the rise in temperature of the gas, and the interior of the product cannot, unfortunately, be shown.

During the first ten hours considerable tar was carried past the cleaning system into the mixing and admission valves and into the cylinder

of the engine; but, owing to one of the properties of peat tar—especially of the tar resulting from the distillation of peat at low temperatures; namely, its complete solution in a mixture of oil soap and water—no trouble was experienced which necessitated a reduction of the load. During the remainder of the test the condition of the producer steadily improved, and the operation of the plant throughout the last ten hours was satisfactory, with the exception of the accumulation of tar on the valve seat and spindle of the gas admission valve, which caused some sticking. To overcome this, a mixture of oil-soap and water was dropped on the valve spindle. At the termination of the trial the producer was in excellent condition, and the gas contained but little tar. Under these conditions the plant could have been operated continuously for almost any period.

The data and results of this test are interesting, since they show that a peat containing more than 29 per cent. of moisture and a calorific value of 9,470 British thermal units per pound gave a brake-horse-power with a fuel consumption of 2.81 pounds per hour under very satisfactory operating conditions.

The by-products resulting from the distillation of peat at temperatures obtaining in the producer consist of heavy and light tars, paraffin oils, ammonia, etc., and the quantity of such products depends, to a very large extent, on the moisture content of the peat when fired. As previously explained, most of the heavy tar is condensed and separated in the water-cooled pipe which connects the upper and lower zones of the producer. This tar drops into the water seal at the bottom of the pipe and takes no further part in the formation of the final producer gas.

The remaining by-products—such as lighter tar and paraffin oils—escape condensation in the water-cooled pipe, and pass into the lower zone of the producer. In passing through the hot peat coke—as explained in the foregoing part of this article some of these light tars and oils interact with carbon and form permanent gaseous compounds; but the physical and chemical character of a part of these tars and oils is not changed, or, at best, very slightly, and they pass with the final producer gas to the cleaning system.

In passing through the coke scrubber a large amount of the lighter substances is separated out and passes off with the cleaning and cooling water, while a large amount of the products still remaining is separated out in the tar filter, which is continually washed by sprays of hot water. The wet coke scrubber and the tar filter separate the bulk of these products from the gas and leave it comparatively clean.

According to the temperature conditions obtaining in the producer and the moisture content of the peat when fired, the gas after it leaves the cleaning system still contains more or less tar carried in a very finely divided state, which gives the gas the appearance of a fog or mist.

It is evident, therefore, that the formation of the final producer gas—or, in other words, the gas which leaves the producer—can only be altered by varying either the internal temperature of the producer or the moisture content of the peat. When the moisture cannot be varied, the temperature can only be increased or decreased by increasing or decreasing the load carried on the engine.

The lowest average temperature occurred in the test of one-fourth load, being about 170 degrees F. The peat used during this test contained the highest percentage of moisture—viz., 37.5 per cent.; but the tar carried by the gas past the cleaning system was scarcely noticeable, and caused absolutely no inconvenience whatever in the operation of the engine. The distillation products during this test consisted mainly of paraffn oils, which were either partly separated by the cleaning sys-

tem before entering the engine or passed into the engine, these being burned in the combustion chamber along with the permanent gases.

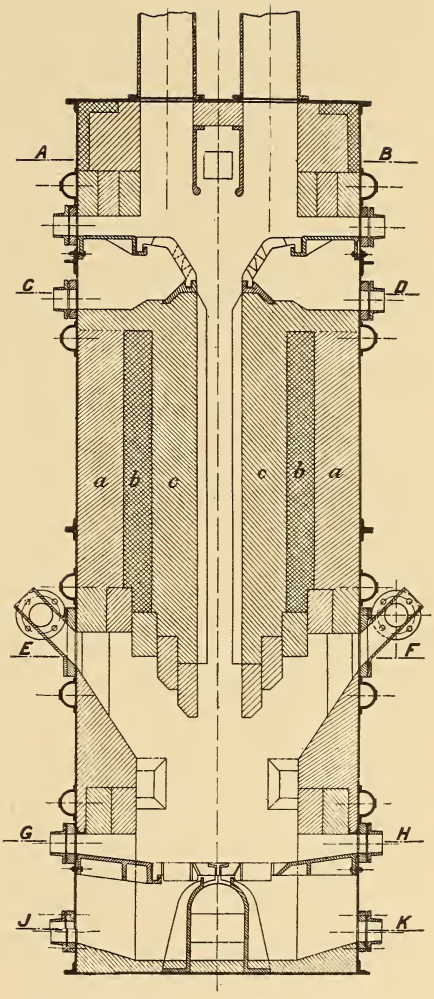
The temperatures prevailing during the one-half and three-fourths loads were considerably higher, while the character of the by-products was noticeably different, both physically and chemically, the percentage of light tars being quite predominant. The gas during these two tests was, however, remarkably free from tar.

The greatest amount of tar was formed during the test at full load, the amount of paraffin oils being comparatively very small. The average temperature during this trial was higher than that obtained during any of the former trials at lower loads, reaching about 430 degrees.

The results of the original experiments in the use of peat fuel in the gas producer led to the belief that certain modifications in the producer itself would eliminate the production of tar. These modifications included alterations in the shape of the upper portion and in its lining. The first changes in these respects were not wholly satisfactory, but further tests by the engineers of the Fuel Testing Division demonstrated that it was impracticable to burn or split up the tarry components of the gas evolved in the upper zone into permanent combustible gases, and that some improved method of cleaning the gas would be necessary.

After considerable experimentation Mr. Haanel succeeded in devising a cleaning system which effectively separated the tarry matter from the gas, which enabled the engine to be run for many days without requiring cleaning of the valves. The piston does not require cleaning more than once or twice a year if the plant is operated continuously.

The improved producer is shown in the illustration, the principal change being the lengthening of the contracted neck *G*, this involving a very thick lining at that point, a fact which was taken advantage of for the purpose of decreasing the loss of heat through radiation.



IMPROVED GAS PRODUCER FOR PEAT FUEL

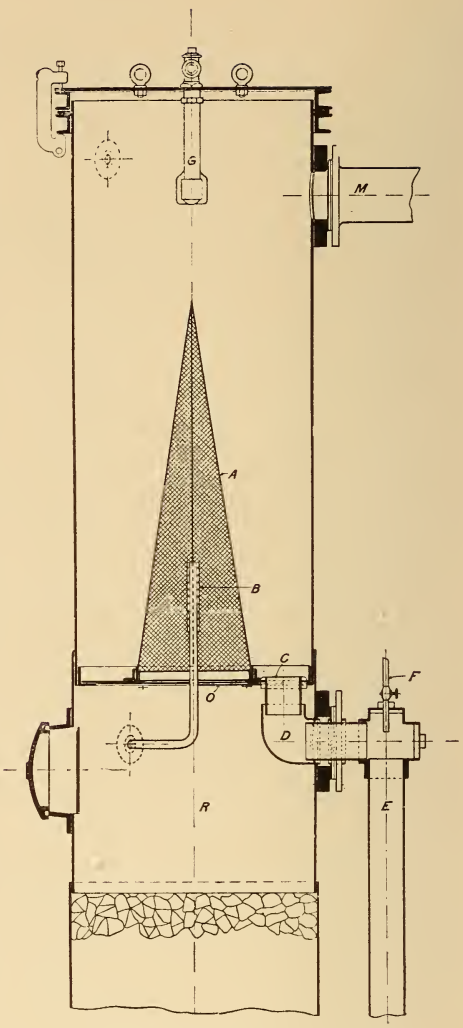
In the producer as originally constructed the gases evolved in the upper zone were partially drawn down through the contracted neck *G* to the two gas off-takes, and did not all pass through the incandescent fuel of the lower zone; consequently, the tarry components of the gas were neither burned nor split up into permanent combustible gases. The producer, when operating in this manner, was up-draft in the lower zone and partially down-draft in the upper zone, the gases generated from both

mixing at the off-takes. The amount of tar formed, or which escaped the producer unchanged, depended on the ratio of the amount of gas passing down through the contracted neck to that passing through the pipe. This ratio was varied by the restriction of pipe caused by the adherence of tarry matter to its walls. As originally constructed, therefore, the operation of the producer was irregular, delivering at times a gas comparatively free from tar and at other times one heavily charged with tarry vapours.

To overcome this difficulty and to ensure the passage of the gas from the upper to the lower zone through the pipe provided for this purpose, the contracted neck was made sufficiently long to increase the resistance necessary to prevent any appreciable quantity of gas from being drawn down through the same. With this new construction it is probable that all, or very nearly all, of the gases evolved in the upper zone are conducted to the chamber under the grates of the lower zone, where they pass through the grates and mix with the air admitted through the air-openings in the doors of the ash chamber.

The objective of drawing the gases in this manner through the incandescent peat coke of the lower zone is either to cause the tarry vapours to burn when mixed with the air or to be split up into permanent combustible gases. This is realized to a certain extent, but a quantity of the tarry vapours generally escapes combustion or decomposition and must be separated out in the cleaning system.

The bulk of the tarry matter is removed in the coke scrubber and tar filter; but even under the best conditions tar in a very finely divided state is carried in suspension by the gas past the entire cleaning system to the engine. Here it is deposited on the mixing admission valves and in the cylinder, where it becomes partially carbonized, causing the



TAR SEPARATOR FOR PEAT GAS PRODUCER

valves and piston to stick. Whenever this occurs it is necessary, in order to ensure regular operation of the engine, to thoroughly cleanse the cylinder and valves with a mixture of oil-soap and water, as already described.

In order to determine the conditions under which tar fog would separate out from the gas and how these conditions could be applied in a simple but effective manner to a cleaning system, experiments were undertaken upon the effect of varying the velocity of the gas. It was

found that when a gas, heavily charged with tar fog, was passed through a contracted passage and then allowed to expand, the tar condensed into small globules, so that a separator could be designed upon this principle.

This idea is put into practice in the apparatus shown in the illustration, in which the gas passed through the wire mesh cone *A*, this cone being cooled and washed by a water spray *B*. The drops of separated tarry vapour fall down into the chamber *R* and on through the coke of the scrubber.

The action of the cone screens in eliminating the tar is two-fold: (1) In producing coalescence of the fog particles by impact with the solid parts of the screen; (2) causing coalescence of the fog particles by crowding together the stream lines as the gas passes through the fine meshes of the screen and retarding the particles by friction with the internal surface of the meshes.

When the suction shows a tendency to increase the cold water at *G* is turned off and the hot water turned on, which thoroughly cleanses the cone in a very short time at an expenditure of a very small amount of water.

An automatic arrangement is being devised whereby an increase in suction will instantly turn off the cold and put on the hot water, and vice-versa. By this device the consumption of both hot and cold water can be reduced to a minimum.

In ordinary practice, however, it has not been found necessary to resort to the hot water spray more than two or three times during a ten hours' run. In order to maintain a straight and normal suction curve during the entire period of operation a simple automatic arrangement for changing from cold to hot water and vice-versa would be an advantage. But while this would prove an advantage it is in no sense a necessity.

The water consumption for cleaning with this new system is not increased over that of the old, which was very small.

The gas, after leaving this cleaning system, is sufficiently free from deleterious material so that it can be used in the gas engine without any trouble whatever. Moreover, the cleanliness of the gas is not dependent on the perfect operation of the producer itself, but permits of a large variation in the conditions governing its operation. For example, the cleanliness of the gas—its freedom from tarry matter as it leaves the producer—depends (1) on the moisture content of the peat burned; (2) to some extent on its quality, and (3) quite considerably on the amount of air admitted to the two zones. Close and careful regulation is, therefore, not so essential to the cleanliness of the gas leaving the cleaning system as it was with the former construction, although obviously an advantage in so far as the waste of tarry matter is reduced.

WELDING BY MACHINERY

By James Steelman

THE oxygen acetylene flame for welding and cutting metals has many applications, even when used by hand alone, and some examples of this usefulness have already been given in previous articles. The substitution of machinery for hand work wherever practicable, however, is the great characteristic of modern methods, and hence it is of interest to examine how this powerful tool has been adapted to mechanical control.

Apart from the desire to replace human labour by machinery, it is found that a number of difficulties appear to the use of hand work in certain lines of commercial work.

For example, in seeking to unite very thin sheets by means of an ordinary butt joint, the hand of the operator cannot be depended upon to give precisely the right speed to the torch as it is carried over the seam. If the flame is given too rapid a movement, the weld is either not made at all or it is imperfectly done. If the movement is too slow, the work will be burned away, so that patching becomes necessary. Further, the operator may vary the vertical position of the flame, introducing a new complication, since this irregularity will result in a fluctuation in the amount of heat supplied. In order to get the best results in the minimum of time, it is better to maintain the torch at a constant angle, to keep its position vertically and transversely in a fixed nearness to the joint, and to move it at a precise rate of speed.

These requirements cannot be met at the best commercial rate of speed by means of the hand of the operator, but they can be met by means of specially designed machines.

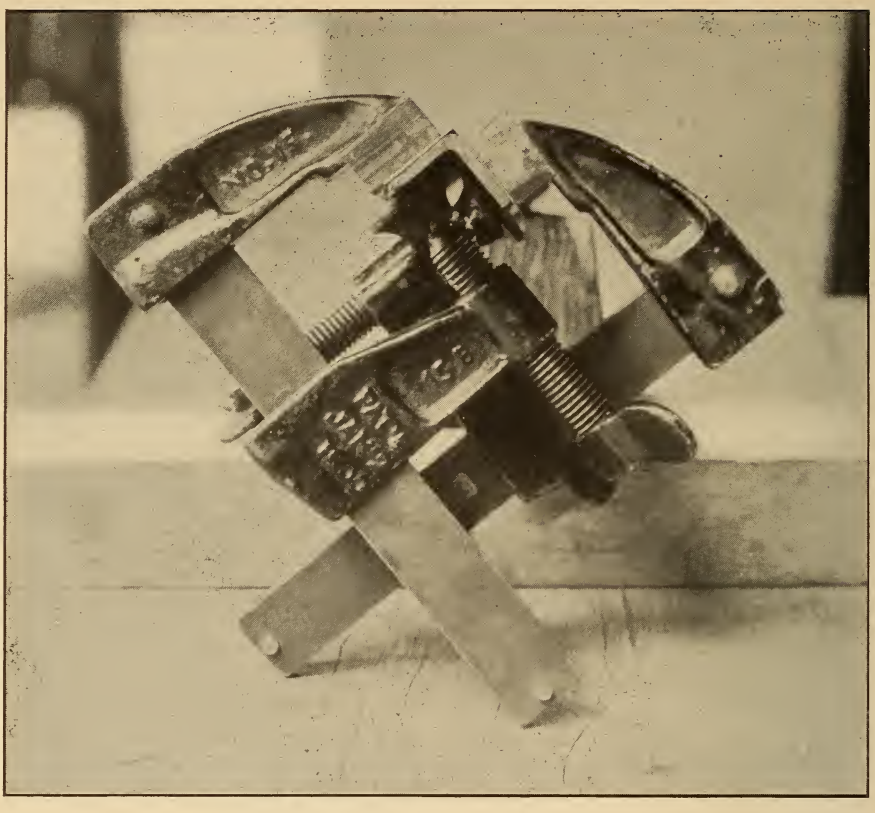
These divide themselves into two classes—those where the work is fixed and the torch is moved, and those where the work is carried beneath a fixed torch. For some work the choice of method is a matter of indifference; for other work it may be imposed by the conditions.

A very recent machine is one designed and built by the Davis-Bournonville Company, of New York City. The same machine may be used for the cutting of steel. The torch is here given the movement and the work remains fixed. There is a substantial vertical post of six or seven feet in height. A kind of sliding sleeve envelops this post. As this sleeve is provided with a pinion and the post with a rack, the vertical position of the sleeve can be readily controlled by the operator. On the side of the sleeve diametrically opposite to the pinion there is a projecting bracket in which is arranged one end of a hollow cylindrical arm. This arm extends horizontally for 6 or 7 feet. A brace extends from the upper part of a kind of collar arranged on the outer end of the arm to a point at the upper end of the sleeve on the vertical post. In the hollow of the horizontal arm a shaft is arranged which is provided with a bevel gear on the end next the post. A second bevel gear is horizontally arranged to mesh with the first. The second one is driven by a vertical shaft which passes through it. The gear slides vertically on the shaft, which remains in a fixed position. When the sleeve on the post is raised or lowered, the vertical shaft is still competent to effect the drive of the horizontal shaft in the arm. A screw is rotatably arranged in a horizontal

position just above this arm. By means of a change-gear arrangement at the outer end of the arm, the screw may be driven at speeds having a variety of ratios to the speed of the vertical shaft. The speed is always reduced, however. At the base of this shaft a horizontal friction disk is arranged. This is driven by a friction pinion mounted on a short horizontal shaft. On the outer end of this shaft are a tight and a loose pulley. The friction pinion may be moved toward or from the center of the disk. It will be seen from these arrangements that a range of speeds can be transmitted from the countershaft to the vertical shaft. Each of these speeds may be reduced in accordance with a set of fixed ratios determined by the gears on the outer end of the arm. The result is that, for every speed of the vertical shaft, we shall have several speeds of the screw. The screw has six threads per inch and controls a carriage which slides on the horizontal arm. The carriage is provided with a holding device in which the torch is removably secured. The angle of the torch can be adjusted, and also the vertical position of the tip. The carriage can be readily released from the control of the screw and a quick advance or return made.

We have thus a power-driven mechanism competent to give a very uniform motion to the torch at any one of a considerable range of speeds. The angle of the torch is maintained and also the movement in a straight line. Vertical adjustment of the arm to accommodate the conditions of the work is easily obtained by the operator.

Pretty much any and every kind of sheet welding can be done by this machine where the joint is accessible, straight, and does not require a circular movement of the torch in addition to the forward motion in order to cover a wide track. There is a considerable range of work which falls within the limitations stated. Once the forward speed for a given line of work has been determined, welding may be done by comparatively unskilled labour with uniformity and precision. For example, it may be ascertained that a forward speed of 10 inches per minute is the precise rate suited to the welding of a certain type of joint made by the edges of a given thickness of sheet steel. The speed once ascertained, the judgment of the workman will not be required to redetermine it from time to time during the progress of the work. If holding devices be employed of such character that the work cannot be misplaced, about the only thing the operator will have to do that requires judgment will be to see that the proper pressures of the acetylene and the oxygen are maintained, and that the character of the working flame does not change. The ability to do these things is readily learned. There is no welding wire to manage. The whole subject should be carefully studied by the foreman who designs and arranges the work for the machine. He will see that there is a range of possibilities for the supplying of welding material from the work itself. In machine welding, especial attention must be given to securing the work. The working point of the welding flame will move in a straight line placed horizontally. The edges of the joint must be arranged with this fact in view. A portion of the joint which drops below or rises above the standard level may be sufficiently displaced to require a variation in the forward movement of the torch because of the change in the heating conditions. The holding device should be of such a character that the edges are kept throughout at precisely the same level. Again, if the joint varies to the right or left of the line of movement, there will be a variation in the heating results in the joint. The holding device must, accordingly, be designed to cover this point. In general, the requirements as to exact placing of the edges in accordance

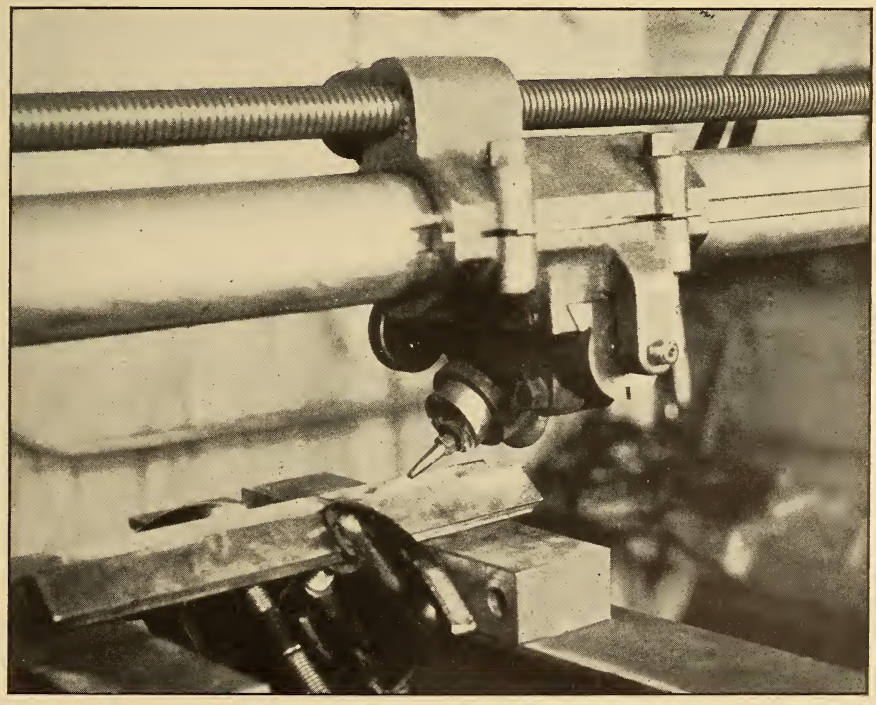


CLAMPS FOR HOLDING ANGULAR WORK FOR WELDING

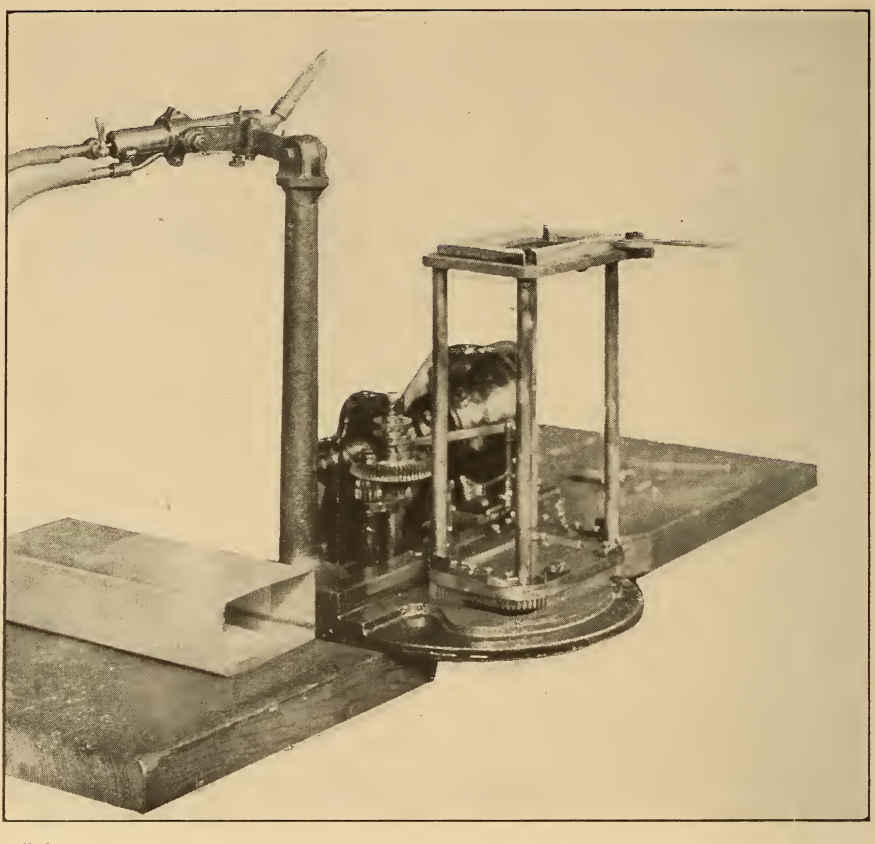
with what has been explained will not be difficult to meet. But they must not be neglected.

In many cases where machine welding is employed, it will be possible to eliminate discoloration from oxidation of the surface metal. Thus, the oxidation of steel can often be prevented. Iron oxides are formed at various temperatures. Common rust is formed at ordinary temperatures, but ordinarily only in the presence of water or water vapor. Oxygen is, of course, required. The welder does not have to fear this oxide. However, there is another oxide formed at a pretty high temperature which frequently gives trouble. If oxygen is not present, or is not present until the temperature has fallen below the point at which it forms, then it is not to be feared either. Now oxygen may reach the weld in two ways—it may come (1) from the oxygen supply passing through the tip, or it may come (2) from the atmosphere. With regard to the first possibility, it may be said that a certain portion of the oxygen coming through the tip is required in order to consume the acetylene to carbon monoxide (CO) in the working flame. For this purpose, the oxygen is required to equal the acetylene in volume. That is, the ratio of oxygen disposed of to acetylene furnished is 1 : 1. In actual practice it has not been found possible to employ quite so small a proportion of oxygen. It has been found possible in at least one style of blow-pipe to make the ratio as low as 1.28 : 1. It is probable that the carbon monoxide and hydrogen passing through the little flame are competent to make harmless a certain proportion of excess oxygen. It will be best, however, to use apparatus

where this excess is kept as low as possible. But, even with the best of apparatus, some attention is required to keep the flame to exact form. This is not difficult and means when accomplished that the minimum proper amount of oxygen is being supplied. With regard to the second source of oxygen—the surrounding atmosphere—it is necessary to take especial precautions. There is probably no difficulty at all immediately under the point of the working flame where the heating is being done; the temperature is probably too high and the work is covered by the flame. But, after the torch passes, the temperature will fall and oxidation from the atmosphere is to be feared. A solution lies in excluding the atmosphere. In many cases, this may be done in a simple manner and without expense. I am speaking now of the top side of the joint. If the clamping irons to either side of the seam provide a narrow and rather deep canyon, the outer flame will ordinarily be split into two streamers. One of the streamers of flame will extend for a distance along the bottom of the canyon ahead of the working flame; the other will likewise extend along the bottom to the rear. The streamer which follows the moving torch will exclude the oxygen of the atmosphere from the work; or, rather, it will dispose of it by chemical union with it. The outer flame is hot, but it possesses only a moderate temperature as compared with the little working flame. Consequently, after the new weld has passed for a distance beneath the rear streamer, it will be comparatively cool. All that is necessary as the weld comes into the air is that the temperature be below the oxidation point. In any particular case, one can readily determine whether the arrangements are adequate. If the size of the streamer is not sufficient to provide a protective covering that is long enough and thick enough, then an auxiliary flame may



MACHINE FOR WELDING ANGULAR SHEET METAL

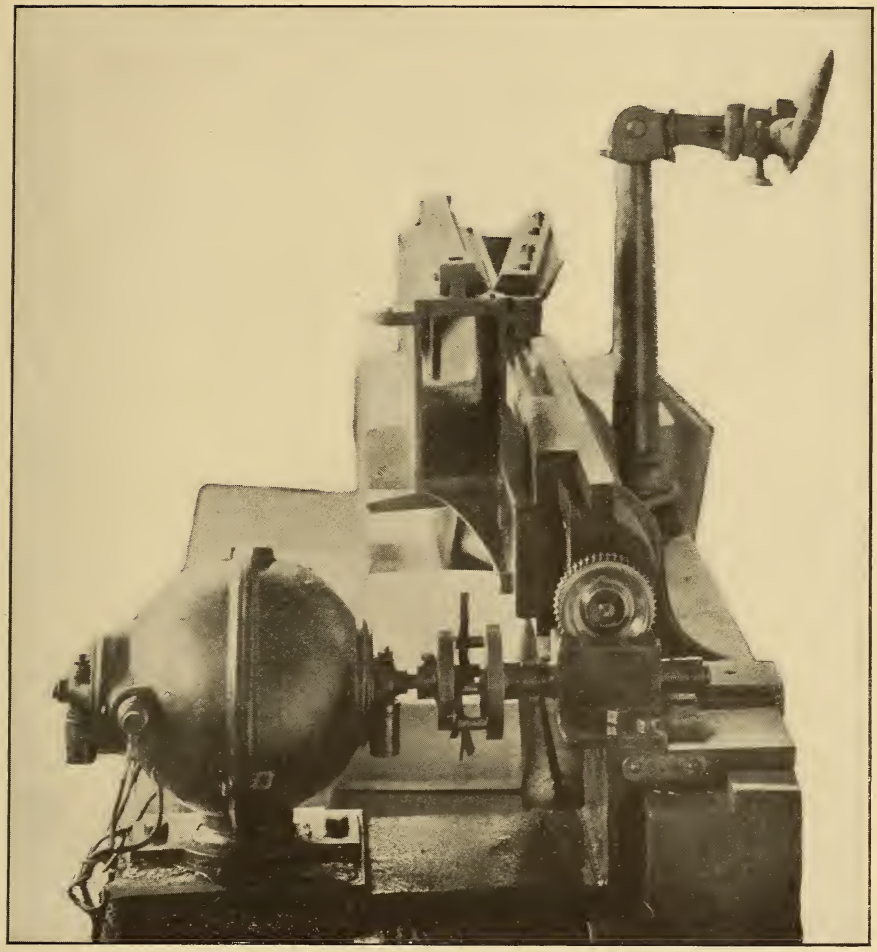


AUTOMATIC WELDING DEVICE USED ON EDISON STORAGE BATTERY WORK. THE HOLDING DEVICE IS EMPTY AND THE TORCH THROWN BACK

be used. This should be a reducing flame. A hydrogen jet would be very suitable. This could be arranged to intermingle its flame with the streamer by using a nozzle suitably attached to the under part of the oxy-acetylene torch. The tip of the hydrogen nozzle could be curved backwards, if that seems desirable.

To form the narrow canyon between the clamping irons, arrangements should be such that their lower edges hug the seam pretty closely and that their faces make a steep angle with the horizontal. If they are beveled at 60 or 70 degrees, this result will be attained. To make the canyon deep, we have only to see that the clamping irons are thick. For very thin steel, an inch or an inch and a half will perhaps be thick enough. For heavier sheets, it may be necessary to increase the vertical depth of the faces. The idea is to confine the streamer so as to make it provide a long and thick covering.

In applying this method, the movement of the torch should be continued beyond the end of the seam in order that the rear streamer may have opportunity to perform its duty with reference to the final portion. It may be found necessary also to begin the torch movement somewhat before the work is reached. In either case the clamping irons should provide the canyon-like channel for the full length of the torch movement in order to furnish a means of forming the streamers. It is not very clear just why it should (in some cases, at least) seem advisable to begin protection—

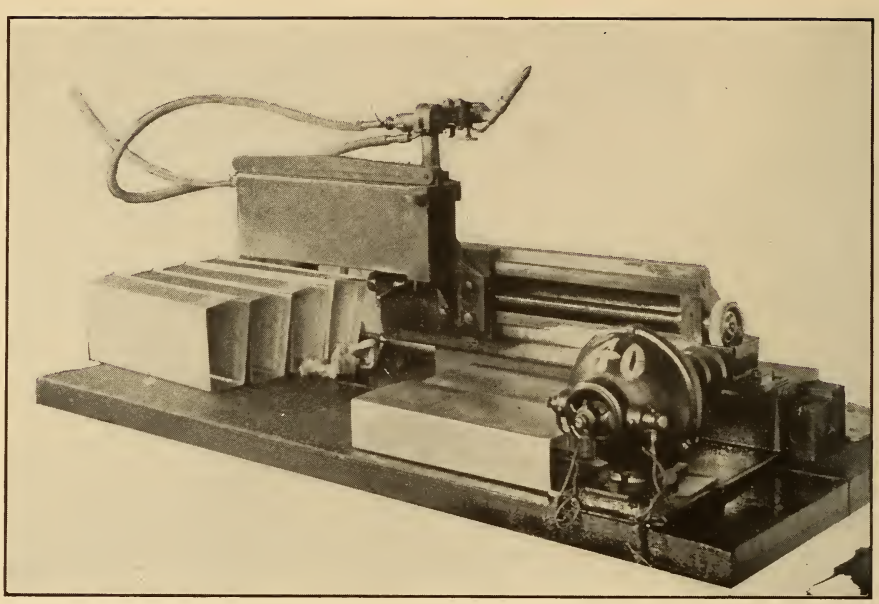


AUTOMATIC MACHINE FOR WELDING LONGITUDINAL SEAMS IN EDISON STORAGE BATTERY CAN. TORCH THROWN BACK AND CLAMPS EMPTY

and with the forward streamer—before the work is reached. However, the reader is advised as to what appear to be the facts.

The foregoing provisions deal with the upper surface of the joint. In some cases the character of the work or the form of the joint is such that we need not concern ourselves with the under portion. Thus, for example, where the joint is formed by welding together the edges of contacting flanges, there may arise no discoloration on the under surface because of the moderate temperature reached at that point. In other cases, however, it will be necessary to provide especial means. This may be done, under suitable circumstances, by arranging one or more reducing flames along the seam on the under side of the work. A suitable slit may be cut in the supporting table and the reducing flames so arranged as to provide a protective covering sufficiently wide and thick to meet the special conditions.

In perhaps the majority of cases of welding sheet metal, the question of discoloration of the surfaces is a matter of no importance. Under such circumstances the foregoing directions and suggestions may be disregarded. However, the splitting of the outer



SIDE VIEW OF MACHINE FOR WELDING SEAMS IN EDISON STORAGE BATTERY CAN, SHOWING SCREW FEED

flame by the canyon-like arrangement of the clamping irons has a value apart from the question of discoloration. The forward streamer certainly has a heating effect upon the edges to be welded. This will facilitate the work of the little flame and make possible a more rapid operation of the machine. This preheating is accomplished without expense. Where the canyon-like arrangement is permissible, it should accordingly be employed as a method of partially utilizing the heat of the outer flame.

The manufacturer of sheet metal articles may have welding operations whose character and frequency are such as to make a special machine desirable. It will be of advantage, then, to consider how some special requirements have already been met. What has been done is often suggestive of what may be done.

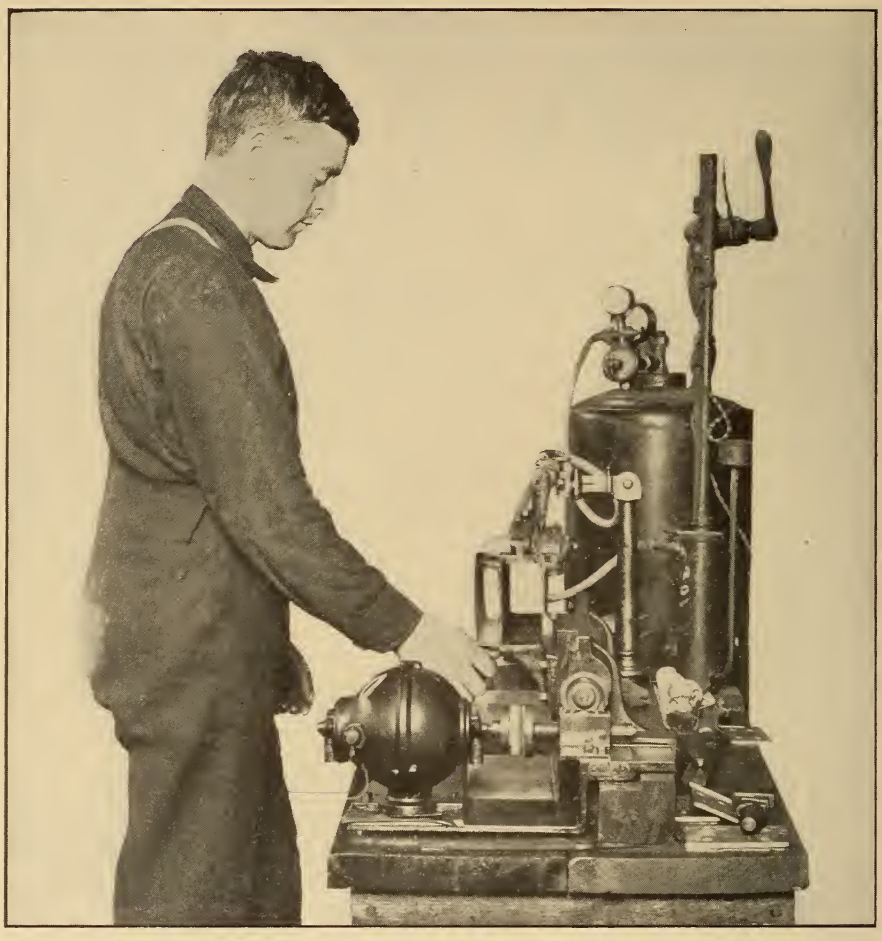
The Edison Storage Battery Company, of Orange, N. J., employs two special oxy-acetylene welding machines in the fabrication of the containing cans of the elements of their battery. It is necessary that these cans shall be absolutely tight; it is probably not especially essential that the joints have the full strength of the metal. The material employed is sheet steel which has been nickel-plated in advance of the welding operations. Two thicknesses are employed—0.015 and 0.025 inch. This is pretty thin material. To weld it by hand with an edge-to-edge joint would probably be expensive, but perhaps not prohibitively so. The Edison people, however, are doing this work in a highly commercial way, as anyone would grant upon noting the expedition and certainty with which the special machines accomplish the work.

The cans have each a uniform horizontal section, square or rectangular in form. The corners are rounded, however, at a small radius of perhaps a quarter of an inch. Some of the cans have sections of, say, 5×5 inches; others of, say, $2\frac{1}{2} \times 5$ inches. Vertically, the cans are perhaps 15 inches in height. There are three seams—one where the edges of the single sheet forming the wall are united; two where the top and bottom are secured to the wall. The vertical joint is made by welding together the edges of flanges which are at right angles to the wall. The flanges are in

AUTOMATIC MACHINE FOR WELDING LONGITUDINAL SEAMS ON EDISON STORAGE BATTERY WORK

contact, face to face. An important point to notice is that this seam does not run along a corner, but is located a little to one side. The weld is made by fusing the edges, which are side by side, and permitting the material to intermingle. No welding wire is employed. The seams at top and bottom are identical. The top or bottom is formed in a power press in such way as to provide a flange all around the periphery. This flange is perpendicular to the general surface of the piece and is perhaps 3/16 or ¼ inch deep. There are no joints where the flange turns the corners, or anywhere else. This piece is set in the body of the can, with its concave side on the exterior, and its edge flush with the edge of the wall. The two edges, side by side, are then fused together, just as in the case of the vertical seam. From a welding point of view there is no difference between a top and a bottom. A welding wire is not employed.

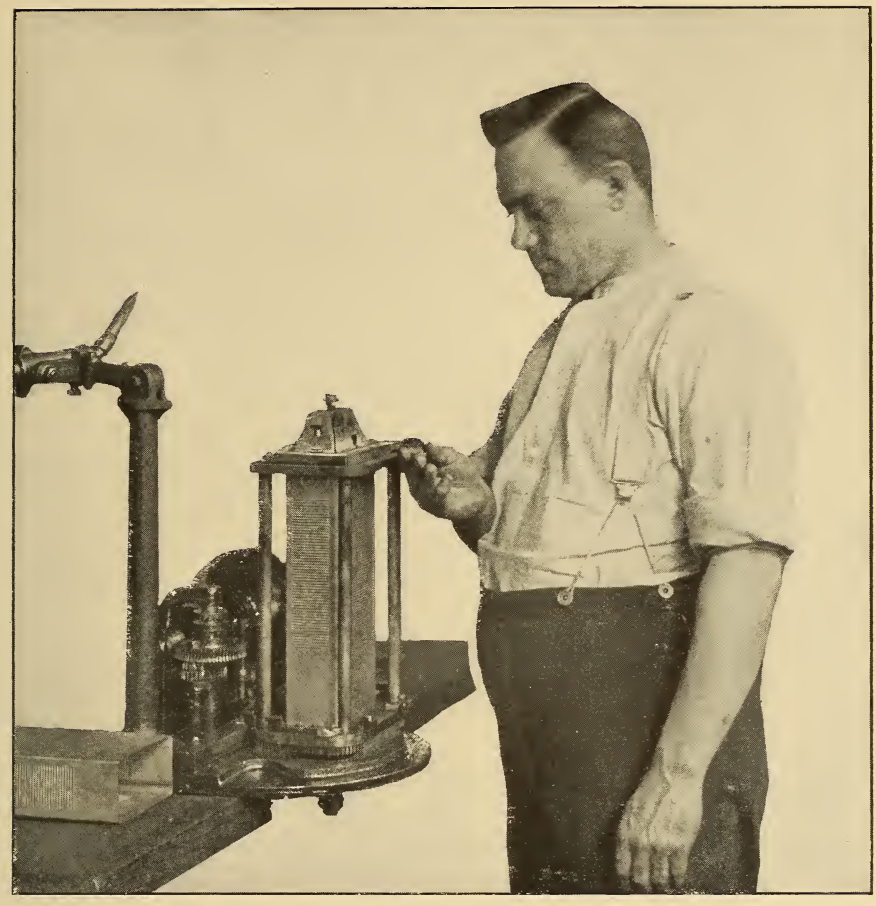
In both machines it is the work which moves; the torch remains stationary. A suitable post stands on the left and to the rear. Upon this is arranged a holding device for the torch. The holding device is hinged to permit throwing the torch back and out of the way when its service is not required. Both types of machine are operated by little individual motors. The drive is transmitted by means of two small disks, one on the motor shaft and one on the driven shaft.



LONGITUDINAL WELDING MACHINE, SHOWING WORK AND TORCH IN POSITION

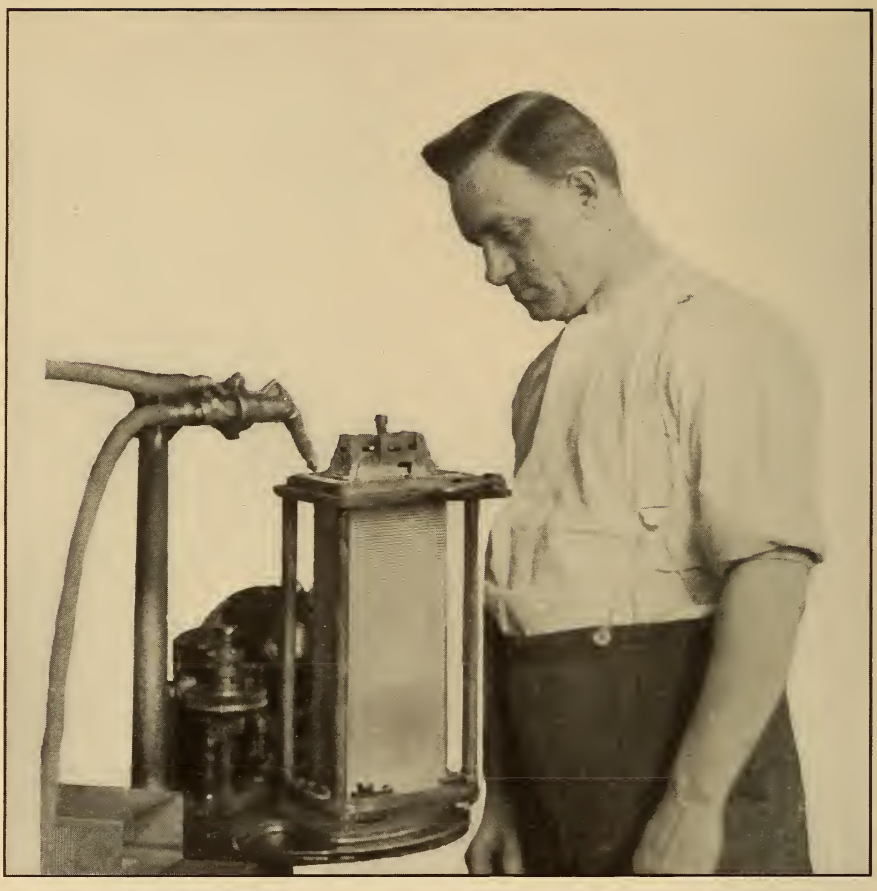
Each of these is provided with two little pins or studs projecting from the face of the disk; these are set diametrically opposite each other. The two disks are so placed as to have the pins of one overlap those of the other. A leather string wound in and out among the pin secures the two disks to each other in a way to limit the strength of the connection. A projecting end of the strand does not threaten the hand of the workman as a loose piece of wire would do.

The machine on which the vertical seam is welded is provided with a suitable carriage. The body of the can—without top or bottom—is slipped onto a holding device arranged on the carriage; the vertical seam is placed horizontal with the edges standing up. There are two clamping irons. One moves in a vertical plane on a hinge arranged at one end of the holding device. This clamping iron is brought down upon the work and clamped in position. It is on the side of the seam next the operator. A second clamping iron is also hinged to the holding device and at the same end of it as in the former case. But this second iron moves in a horizontal plane. It has two clamping surfaces at right angles to each other. When this iron has been locked in clamping position, it holds in place the narrow strip of horizontal wall on the side of the seam away from the operator, and also a strip of vertical wall. When both



AUTOMATIC MACHINE FOR WELDING STORAGE BATTERY CANS. TORCH THROWN BACK, CAN IN POSITION

irons are secured we have the following condition of affairs: The horizontal surface to each side of the seam is securely held in place. Also, the vertical surface adjacent to the nearby corner of the work is clamped tight. The flanges of the work which form the seam lie between faces of the two clamping irons. These faces together make a narrow and rather deep canyon-like groove with the seam at the bottom. Each face is inclined at an angle of about 60 degrees to the horizontal. The surface of the holding device immediately beneath the seam is provided with a groove in order to avoid the presence of metal in actual contact with the under surface of the joint. One effect of these arrangements is to split the outer flame into two streamers, filling the bottom of the canyon to front and rear of the inner or working flame for a distance of perhaps 4 or 5 inches with a fairly deep body of reducing flame. As there is an air space beneath the joint, and as air is a very poor conductor of heat, the loss of heat by conduction and subsequent dissipation through radiation is reduced. As the work moves beneath the torch, which is set at an angle of about 45 degrees, the streamers operate to preheat the work and to prevent discoloration through oxidation. There is often—perhaps always—some discoloration at the two ends of the seam. It would seem that this might be avoided by extending

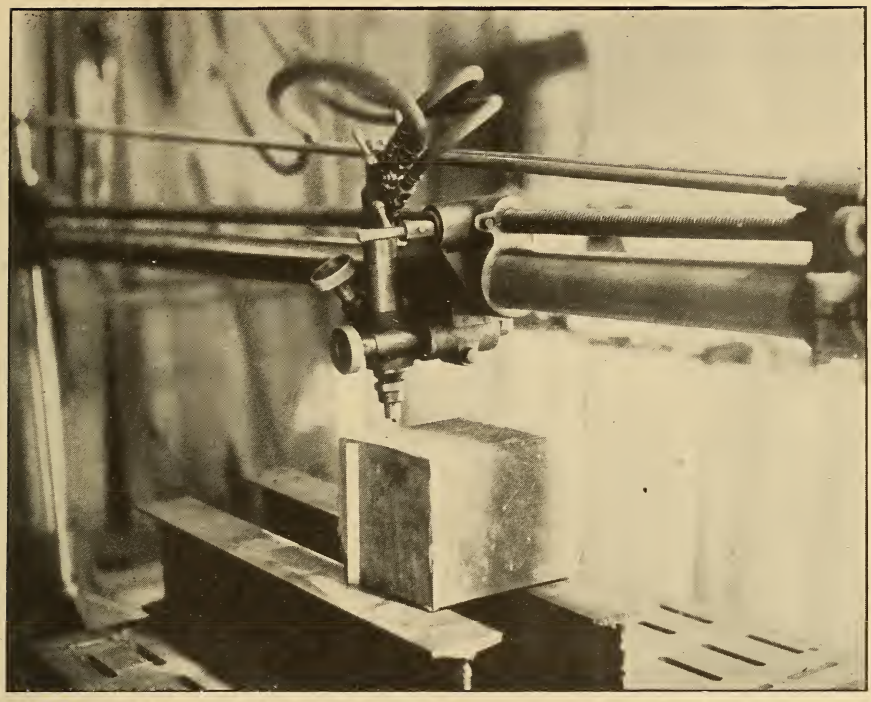


MACHINE FOR WELDING BOTTOMS ON STORAGE BATTERY CANS, TORCH AND CAN IN WELDING POSITION

the movement so as to make the torch overrun at both ends and extending the clamping irons to correspond. The facts are that at present the major portion of the seam can be commercially welded without discoloration either of the nickel plating or steel edges.

The carriage movement is secured by a screw. This in turn is driven by a worm gear meshing with a worm on the shaft driven by the motor spindle. The motor rotates, of course, at a high rate of angular speed. By means of the worm-and-gear and the screw the carriage is given a slow rectilinear motion of perhaps 8 or 10 inches per minute. It requires about 1¾ minutes to perform the actual welding operation. Putting on and taking off the work, and throwing the torch in and out of position increase the total requirement to perhaps 2½ or 2¾ minutes. Calculating 20 welds per hour and the labour at 30 cents per hour, we have a labour expense of $0.015 per vertical seam. The gases will cost perhaps 1.5 times as much as the labour, and thus make the total expense for labour and gases $0.0375 per seam.

The welding of the tops and bottoms onto the shell produced by the foregoing machine is a more complex problem. The shell is held in normal position in a holding device. Within the concavity of the top or bottom a special device is placed which can be opened to spread the flange simultaneously in four directions. Correspond-



UNIVERSAL MACHINE ABOUT TO CUT HEAVY STEEL BLOCK

ing to this, there is a clamping device outside of the wall of the shell which holds the exterior part of the joint to an exact size and form. This device may be opened and closed, and so provides for ease of engaging and disengaging the shell. That is to say, this clamp is split along a vertical diagonal plane of the can. When the exterior clamp is closed and the interior one opened, the joint is firmly held inside and out. As with the other machine, the entire clamping apparatus is or becomes a part of the holding device. The interior clamp used to expand a top or bottom is a loose piece of apparatus not secured in any way to the main holding device.

The holding device, together with clamps and work, has to be given a motion such that every position of the double edge of the joint will be carried beneath the torch. It is necessary that the movement shall at all times be uniform, if the best results are to be secured. At the same time, a moderate retardation will only result in an irregularity in the evenness of the welded edge. The form of the joint covers this. The weld will be made. The movement of the holder is secured through a rack arranged beneath the floor, or. bottom, of the holder. The pitch line of this rack has precisely the form of the plan of the can. Necessarily it describes a larger rectangle. The reason for this is the sharp curvature of the corners of the plan. As a matter of fact, the radius of curvature of the plan is considerably smaller than that of the pitch line. Now the linear speed of the pitch line of the pinion which drives the rack will give the same rate of movement to the straight portions of the plan. But at the corners the plan movement would be much less. In order to get uniformity throughout, the pinion is given a much higher speed at the corners. There are eight changes of speed in a complete cycle—two at each corner. However, the design of the machine is such that these changes are brought about automati-

cally. No attention is required from the operator. The machine is so constructed, however, that the rapid movements around the corners can be hand controlled, in case the automatic speed-change device should be temporarily disarranged. This requires no really irksome attention on the part of the operator.

The whole apparatus is driven by a horizontal worm direct connected to the individual motor, as in the case of the other machine. Here, however, the worm gear rotates in a horizontal plane. The direct drive of this gear is communicated to a spindle which effects through gears, etc., the drive of the rack around the corners. The necessary speed reduction for the straight movements is accomplished through certain little gears arranged on a vertical stud projecting vertically from the under surface of the worm gear.

In Germany the application of the gas welding machine to the manufacture of the smaller diameters of tubing is no theoretical process. It is hard to say what diameter is the upper limit, as there are one or more styles of welding machine which broaden the track of the torch, and thus permit grooves other than the narrowest to be heated. Specially formed edges permit the elimination of the wire. We shall probably not be far wrong in saying that at present the well-ascertained practice in the machine welding of tubes is only limited at the point where wire must be employed.

Tubes that are rolled for machine welding must be formed with considerable precision. This applies not so much to the question of roundness as to the character of the joint. If the welding is to be done upon edges which have been unprepared, it will be important that closure be really effected. Edge should be in actual contact with edge. In many cases this will require that a natural tendency to spring apart must be corrected. Then the levels of the two edges must everywhere match. In short, the joint must be a perfect one. All this it is possible to get. The writer has seen a sample of tubing that had been rolled but not welded in which the joint was so perfect that inspection by the eye was insufficient to determine whether there was a joint. It might have been a piece of cold-drawn seamless tubing so far as his inspection went. There is no doubt, then, that the rolling can be done with all the necessary perfection. As to whether such rolling is commercial, the reader can judge when he learns that a single inexpensive machine has a capacity of 4 miles per 10-hour day for tubing ¾-inch in diameter and having a wall of ⅛-inch.

The stock is in the form of a long ribbon of sheet steel. It first passes between two rolls arranged to rotate in vertical planes, which bend up the two edges of the ribbon. It is important that the curvature shall be exactly that of the finished tube. If the material is elastic a ridge may be put in along the axis of the ribbon, the convexity of this protuberance being arranged upwards. It should not be sharp. Subsequently to the closure of the tube, this interior ridge will be gotten rid of by the use of a proper mandrel. Another pair of vertically rotating rolls receive the ribbon and bend it to form a tube with a very wide opening at the top. It may now be run through a pair of horizontally rotating rolls, which succeed in closing the tube by their lateral pressure. There is, after this, but little to do except, perhaps, force the tube over a suitable mandrel for the purpose of perfecting the form. Such machines are suited for the smaller sizes of tubing—e. g., for those used for gas or water. The wall thickness may be ⅛-inch or less. A separate appliance performs the duty of cutting the tubing off at desired lengths.

In the manufacture of tubes of large diameter, the process of rolling parallel to the axis of the tube is apparently unsuitable. Consequently, the continuous procedure has to be given up in their case. Suitable lengths are fed into machines whose rolling devices have their axes parallel with the

axis of the tube. That is to say, the work begins on the entire length of one edge of the seam. In this way tubes of considerable size can be rolled from sheet metal. Diameters up to 10 inches can be handled by machines already on the German market. These machines handle material up to ¼-inch thick.

The welding machines for the work where no broadening of the flame track is necessary may be quite simple affairs. The essentials are few. First, there must be a means of carrying the length of tubing along at a perfectly regular rate of speed. In one style of machine, at least, this is accomplished by using two pairs of grip or pressure rolls. These pairs are placed a short distance apart. A suitable post and holder for the torch is also required. The third requirement—and a very important one it is, too—relates to the control of the seam. It is very necessary that its position relative to the working flame shall be quite exact. It must not vary either up or down or to right or left. A method of control makes use of a disk with a sharp edge. This is placed at a point a little in advance of the welding position. The edge penetrates into the joint and thus secures control. These are the essential requirements. Preheating, while not essential, is quite important. To effect it, the unwelded tube may be passed through a muffle or similar device. It is said that double the ordinary speed can be attained by preheating.

The writer does not know of its application to the preheating of tubes, but there seems to be no good reason why the outer flame of the torch should not be applied to this purpose. In such a case metal surfaces may be provided on either side of the working flame. These should form a narrow and deep groove with the moving joint at the bottom. They should extend both to the front and to the rear of the working flame. The heat from the outer flame costs nothing extra. The foregoing arrangements could probably be used with advantage even in connection with a special preheating device. They simply provide for the partial utilization of part of the outer flame.

With an absolutely tight joint formed by rolling, the loss of thickness along the weld should be very inconsiderable. Even this slight loss may be obviated by suitably forming the edges to provide material for the purpose.

In the case of tubes having walls too thick to be commercially dealt with in an adequate manner without providing for the penetration of the working flame, the edges should be specially prepared. Indeed, the thicker material will form a groove even if the edges are unprepared. The reason for this is that the exterior circumference of an annular ring is longer than the interior one. If an ordinary strip or ribbon be bent around until the inner edges just touch, there will not be enough material to close the joint on the outside. While the resulting V-shaped groove might perhaps permit the penetration of the working flame, a weld made without additional metal would mark a location of reduced thickness. By giving the edges a very steep bevel and providing a rib along the summit of the bevel, we may arrange adequately for penetration and for new metal.

If it is desired to restore the metal of a steel tube to its original strength, it should be properly annealed in a suitable retort. On the other hand, the location of the weld can be strengthened by providing an excess of material. If this metal overflows the sides of the groove, the width of the heated track of the working flame must be sufficient to fuse the surface with which the overflow comes into contact, in order to secure adequate union. A method has been devised abroad whereby the torch is given a circular or other motion adapted to widen its influence. If the whole circumference of the tube is preheated, an annealing procedure will be a necessity, unless the temperature of preheating is not permitted to rise above the temperature of best grain size.

THE CONTROL OF FIRE IN MINES

UNITED STATES BUREAU OF MINES

(Concluded from October issue)

WHEN it is necessary to seal an area, inclosing an active fire in a mine, all men except those needed for the special work should be ordered out of the mine, as there is nearly the same danger of an explosion occurring as there is when reversing the ventilation. It is usual in connection with such fires to erect temporary brattices of cloth or boards, and then to erect behind these the permanent stoppings of stone, brick, or concrete.

Whether the first stopping should be erected on the intake or on the return, or stoppings on both simultaneously, is a much-discussed question among coal-mining men. In the opinion of the author everything depends upon the circumstances; that is, the location of the fire, its character, size of the headings or chambers, whether the coal bed is flat or pitching, the prior direction of the ventilating current, and whether breathing apparatus and trained men are available.

All agree to the general principle that it is advisable to place the stoppings as close to the fire as possible in order to limit the extension of the fire and to lessen the amount of air or oxygen inclosed. In many fires dense smoke and excessive heat prevent placing the stopping on the return side even if breathing apparatus and electric lamps are on hand. In that case it is manifest that the first stopping must be placed on the intake side of the fire. Under ordinary circumstances the author believes that the stoppings should be put up simultaneously if it is possible to do so; if not, the stopping on the intake should be put up first, and then the stopping on the return should be put up as promptly as possible.

If the stopping on the return side of the fire is put up first, as soon as it is completed the gases have a tendency to reserve their movement because of their further expansion from the heat of the fire and the continued distillation of volatile matter (hydrocarbons) from the coal. Owing to the deficiency of oxygen immediately over the fire, the carbon dioxide is liable to be changed to monoxide and the gases thus to become highly inflammable. If at the same time some relatively fresh air reaches the edge of the fire from the intake side while coals are still glowing, there is liable to be ignition, followed by an explosion.

The explosion may not be a severe one if there is no coal dust present, so it is advisable to wet down in the vicinity of the stopping while the latter is under construction.

If the stopping is put up on the intake side it may be placed very close to the fire, for the men will be working in a fresh current of air. If the first stopping is a temporary one, as it nearly always is, it will not be perfectly tight; the result will be that there will be a slow movement over fire in the same direction as previously, and a tendency to gradual self-extinction from lack of oxygen. When a permanent or tight stopping is put up, the small amount of air or oxygen originally inclosed probably in the course of a few hours has been largely consumed by the fire or at least reduced until the mixture of the gases is below the explosive range.

Sealing a mine fire in the presence

of a considerable amount of methane is a hazardous proceeding. Such a necessity has often arisen in the Pennsylvania anthracite region. Manifestly, when the ventilating current in a gaseous district is gradually reduced as the stopping is erected, the mixture passing over the fire becomes more and more explosive, and unless the active or visible fire is self-damped by carbon dioxide, an explosion is almost inevitable. Under these circumstances the erection of a stopping or stoppings is the last resort. It is best that the temporary stopping or stoppings should be door frames and doors, the doors being closed automatically after all the men have withdrawn from the mine. There are several ways by which this arrangement can be effected. The doors may be hung so that they will close by their own weight or by other weights, but may be held open by connections that may be broken or released. The release may be accomplished by a permissible explosive and time fuse, by electric devices, or by the simple means of a counterweight consisting of a keg of water so arranged that the water will gradually drip away, so that after a certain period the counterweight will be so light as to release the catch and allow the door to close.

An excellent emergency stopping, such as might with advantage be a part of the fire-fighting equipment of every mine or mine-rescue station, is a pneumatic mattress designed in Germany, which can be easily carried to a point close to the fire, and can then be rapidly inflated to fit the heading. It is 14 inches thick, and in other dimensions approximates the size of the headings of the mine. There are central plates to which the hose of a portable air pump can be attached. There is a mica window in this plate for purposes of observation; a valve for sampling gases could be added. The mattress is temporarily supported by four legs, two on either side, which afterwards serve as braces. When the mattress has been tightly inflated it fits into the irregularities of the walls, roof, and floor.

It is stated that the mattress can be put in place and inflated in four minutes. Such rapid setting up would be of great advantage if the conditions were dangerous or if there was not a suitable place for a permanent stopping. On the other hand, the mattress has to approximate the opening in which it must be placed, a necessity that limits its application.

For general emergency purposes the usual method of making temporary stoppings or brattices for ventilation is to nail canvas or brattice cloth on props. To meet the emergencies, enough brattice cloth for several stoppings should be kept, together with some special props and light lumber for framing, at division headquarters. It is also advisable to have brick enough to build at least two stoppings one brick in thickness. Cement can be kept in galvanized-iron cans with tight covers. There should also be kept on hand several short 1½ or 2-inch pipes with gate valves for insertion through such such stoppings, in order to obtain samples of the gases, to measure the temperature and pressure, and to obtain a view of the interior. On the latter account gate valves should be used instead of globe valves. The pipe should generally be placed near the roof, to allow testing for the lighter gases. Sometimes it is necessary to insert a pipe and valve near the bottom of the stopping to observe water pressures or to draw off water that may collect behind the stopping.

It is often necessary to erect permanent fire stoppings if large areas are to be sealed off an indefinite time. As these usually require large amounts of stone, brick, cement, and sand, and considerable time for erection, it is generally impossible to keep sufficient material for their construction in the mine.

Permanent stoppings will in many cases have to be strongly built, for if large areas are inclosed, great pres-

sure may be brought by sudden falls of roof; they must also serve sometimes as water dams. They must be well keyed into the ribs and roof and carefully designed to meet the pressure liable to be thrown on them. Pipes with valves should always be inserted through such stoppings, both for examination and to relieve pressure if necessary.

When a fire beyond control has been inclosed by stoppings or fire walls, there are the following four ways of dealing with it: (1) Flooding it with water; (2) letting the fire stand until it has burned out and cooled; (3) when the superficial fire has been put out, attacking it with fire apparatus with or without the help of breathing apparatus; (4) smothering the fire by introducing gases that do not burn.

The flooding of an inclosed fire area with water is the safest and best method when feasible. However, it is only feasible under exceptional or extreme circustances, as when the area is small and the water can be easily obtained. In such a case the only special precaution is to make the stopping strong enough to withstand the water pressure. In a bad fire when all other measures have failed, the flooding of a district or of the mine itself may be necessary, a method that may involve months or years of idleness and great damage to the mine.

In many cases it has been deemed wisest to allow an inclosed fire to stand until the partial consumption of the oxygen and the damping effect of the gases produced by the fire have put it out and the heated material has cooled. The experience of the engineers and chemists of the bureau is that this process usually takes many weeks or months. In a mine in southern Illinois, three and one-half months after sealing the mine with concrete stoppings over the shafts, the fire revived one-half hour after the seals had been broken and the ventilation established. This mine was considered well sealed. Instances have occurred in which, after more than a year of inclosure, fires have revived. Much depends upon the seal; the concrete stopping may be practically airtight, but the surface around the openings and the linings of the shafts or the drifts may leak air. In the case of underground stoppings the adjacent strata and the coal itself will permit circulation of air. It is not generally realized how great an effect a change of barometric pressure has upon a sealed area. Over an extended period there may be a difference between the lowest pressure and the highest pressure of an inch of mercury. This is equivalent to about 13 inches of water, as shown by a gage, or 67 pounds per square foot of exposed area of fire wall or natural strata.

If the inclosure were airtight, the pressure above and below the average line would be one-half of the above; but this is never the condition in coal strata, which are always more or less permeable to gas and air. The movement back and forth through the strata is usually so rapid that, before the area of high barometer has passed, the barometric pressure within a closed area will often equal that of the adjacent open part of the mine. In other words, no pressure will be shown by a water gage inserted in the stopping. The same condition will be found when there is an extended period of low barometric pressure. It is only when there have been very rapid changes in barometric pressures that a water gage shows much difference between the interior and exterior. Under these conditions, the area is breathing fresh air and exhaling gases as the atmospheric changes in pressure occur from week to week or day to day. Nevertheless, it is best to check this effect as much as possible by plastering or grouting carefully with cement all the walls and also any inclosing coal pillars that may be thin.

If the inclosed space is small, like

the heads of two gangways, and the heated mass not too great, the fire is often out in a few weeks. On the other hand, if the area is large and the mass of fire-heated material great it may burn many months. There is especial difficulty when the roof material is sandstone or of open structure, as in the Pennsylvania anthracite field and in some of the Rocky Mountain fields. In the sub-bituminous district of New Mexico a mine has been on fire for years, causing its abandonment and threatening the adjoining mine in spite of carefully built stoppings. It is evident, therefore, that to avoid serious trouble under such natural conditions one must put out fires at the start.

Many have considered the possibility of putting out more rapidly an inclosed mine fire by introducing gases. Carbon dioxide, sulphur dioxide, nitrogen, carbon tetrachloride, steam, and other gases have been proposed and some of them tried in fighting various mine fires. The chief obstacle to extensive use, as when the entire mine has been sealed, is the large amount of gas needed. In such a case, since life is not involved, the question to be considered is the relative expense of allowing the mine to remain sealed, as compared with the cost of fighting or checking the fire with incombustible gases. This idea, however, seems worthy of further development.

THE PRODUCTION AND USES OF MICA

By J. F. Springer

THE mica industry does not involve any excessive figures. The total value of the mica produced in the United States in 1909 was less than $300,000. The imports for the same year amounted to something over $600,000; so that, altogether, imports and domestic production give a total value less than $1,000,000. For the thirty years, 1880-1909, the weight of *sheet mica* annually produced in the United States ranged all the way from 1,809,582 pounds in 1909 to 35,943 pounds in 1894. The million pound mark was not reached until 1906; in 1908 the production fell below it. However, the 972,964 pounds of sheet mica produced in 1908 was almost as valuable as the 1,809,582 pounds produced in 1909. In the one case the average price per pound was 24.1 cents; in the other 12.9 cents. Mica is scattered over quite a number of States, but the average price per pound of the product varies greatly. Sheet mica from Georgia was worth in 1909, on the average, 5 cents per pound; that from North Carolina, 9.4 cents; from New York, 19.2 cents; from South Dakota, 21.4; from New Hampshire, 21.6; from Alabama, 25 cents, and from Virginia, 50.1. It thus appears that sheet mica from Georgia is only worth 10 per cent. of the value of the sheet mica from Virginia. Mica is found in five other States and one territory—Colorado, Maine, South Carolina, Idaho, Maryland, New Mexico.

However, the mica imported into the United States is more valuable, on the average, than that produced there. In 1909, there was imported 1,846,651 pounds, having a value of $618,813, or 33.5 cents per pound.

In the United States, especially in recent years, there has risen a pretty considerable production of scrap mica. In 1900 there was produced 5,497 short tons; in 1909 this production was less, 4,090 tons. The value per ton in the latter year was $11.26. Of the individual States, South Dakota seems to have produced the most valuable scrap: it had an average value of $16.71 per ton.

Now, while mica is not very important from the point of view of the money value, it is, nevertheless, rather highly so if one looks to intrinsic value. It is a good non-conductor of heat and electricity. Certain kinds of mica are fairly transparent. Such qualities as these make it a very valuable material in the manufacture of stoves, gas lamp chimneys, lamp shades, and especially in the construction of electrical apparatus. Mica is a silicate. It is thus already oxidized, from which fact we can understand its incombustibility. The sheet mica finds its way mostly into the electrical industry. Here it is employed as an insulator to separate one part from another. It is used thus in motors, dynamos, high voltage induction apparatus, lamp sockets, switch boards, electric projection lanterns, etc. In the commutators of direct-current motors and in dynamos where stripes of copper and mica are arranged to alternate, it is important that both the copper and the mica shall wear at about the same rate. For this particular line of service, the mica produced in the United States is not so suitable as some originating elsewhere. Canadian mica, or phlogopite, has about the same degree of hardness as copper, and so makes an admirable associate in built-up parts.

The chemical difference between muscovite, the principal mica produced in the United States, and phlogopite is chiefly this: A large part (three quarters) of the alumina in the American product is replaced by magnesia in the Canadian. Otherwise, the two are chemically almost identical. American muscovite is white or pale yellow in color; phlogopite is amber brown or even darker in hue. All micas, including a third variety known as biotite, are said to have a hardness between gypsum and calcite. Talc is softer.

White mica occurs usually in pegmatite rock. Pegmatite is a kind of granite, the same materials entering into its composition, but in different proportions. A prominent Canadian mine of this mica is located in the township of Villeneuve, Quebec. The pegmatite is white, being composed of quartz and white feldspar, and lies between strata of feldspar and red quartzose gneiss in an almost vertical condition. A drift has been run in from the foot of a hill along the face of the gneiss for a distance of perhaps seventy feet. A shaft has been put down at the drift to a depth of some 60 or more feet, following a couple of fissures in which fine crystals of mica were to be found. One crystal is said to have weighed 281 pounds and to have produced $500 worth of mica.

White mica consists of alumina, potash, silica and water. Mr. Colles thinks that, given these materials and certain conditions, mica crystals will form. Now it would seem that the mica crystals form a subordinate crystal amongst or within great ones of pegmatite. Wherever mica is found there we have feldspar and quartz. It is not true, however, that, where we have feldspar and quartz, there mica occurs. It would appear that the dikes of pegmatite are intrusions into the rocks of the earliest geologic age. Whether these intrusions occurred shortly after or during the laying down of the Archaean rocks, or whether they occurred long afterwards, is, it would seem, a matter not altogether settled. Mr. Colles thinks, especially in so far as the North Carolina rocks are concerned, that the pegmatic intrusions took place shortly after the deposition of the Archaean strata and before they were much disturbed. In other words, he thinks that while the Archaean rocks were still horizontal an injection of liquid material from below rose vertically and spread here and there horizontally. An ideal sectional view presents the appearance of a tree-like form. If we suppose the weight of the strata above very great and consequently the resultant pressure enormous; and consider in addition that we have a comparatively high temperature because of the depth; then, he thinks, we have the conditions which will result in intrusions. The highly heated material will become fused and its specific gravity will be less than the unfused material in the vicinity. Further, he takes into account the expansion of the water in the fused material. There would thus arise a tendency of the fused material to rise and of the unfused to sink, with the result of intrusions at favorable points. When later the Archaean rocks are tilted, the pegmatic intrusions are tilted with it. In this way we may have a nearly vertical dike which originally was horizontal. As to the origin of the mica in the dikes, Mr. Colles thinks that something like the following took place: The mica, the quartz and the feldspar were all together in a homogeneous solution before and after the occurrence of the intrusion. These three then crystallized out separately afterwards. Under ordinary laboratory conditions the fusion points occur in conformity to the order—quartz, mica, feldspar, the last having the lowest point. The presence of the water and the existence of great pressure may have produced some variation. It would seem, however, that the mica solidified prior to or simultaneously with the feldspar, and that the quartz solidified last of all. Certain facts tend to confirm this view. Mica and feldspar are found crystallized in a massive quartz

matrix. Upon feldspar and quartz both are to be found marks of mica plates, showing that the mica solidified early, but possibly but little if any earlier than the feldspar. So much for the mica known as muscovite.

Canadian mica, or phlogopite, occurs not merely in Archaean rocks, but in the most ancient formation belonging to the series—the Lawrentian. As American mica is chiefly associated with pegmatite, so the Canadian mineral is found with pyroxene. This last rocks occurs in the form of dikes, the mica being intermingled. There is no doubt now, though there once was apparently, that the presence of pyroxene is due to intrusive action. It was at one time thought that the pyroxene belonged to the Lawrentia beds, because of observed conformity with them. But it is now clear, from the fact that pyroxene dikes "cut across the stratification of the gneiss and associated strata and penetrate these rocks at all angles like dioritic dikes." In working the pyroxene rock there is apparently no limit of depth—1,100 and 900 feet have already been attained.

In contrast with the mining of asbestos, the exploitation of mica deposits in Canada would seem to be best carried on underground. The "open quarry" method has the marked disadvantage that often a great deal of unproductive material has to be handled. Besides, operations can scarcely be carried on the year round. If there is a well-marked vein a shaft may be put down on the foot wall. Side drifts may then be made at intervals. In this general way the mica is opened up. If the mica occurs in pockets, a usual method is to sink a shaft at an angle. The pockets uncovered will be cleaned up and the shaft carried further. Side drifts may be run here and there; but it is largely a matter of guesswork.

In recovering the mica itself, care has to be taken not to damage the sheets. The necessity for this care has its effects upon the methods employed. For example, hand drilling prevails in the immediate neighborhood of the mica. The blasts are light for the same reason. As to machine drilling, it is said to be usually impossible to place the drill in the position demanded by the peculiar location of the mica crystals in the rock matrix. Having fired the light blasts and merely loosened the rock, the hand pick will be used, or at times—if the crystal appears to be unusually valuable—the hammer and chisel. The hand drilling is a most primitive operation. One man, for example, will turn the drill of octagonal steel one inch in diameter, while two others alternately use sledges or hammers weighing perhaps six or seven pounds. If the pyroxene is quite hard the three men will accomplish one and a half or two feet per hour. The labour cost is about 20 cents per foot. The holes have a maximum depth of about four feet. However, machine drilling is said to be employed by the larger mines in development work. Compressed air and steam drills are both in use. The compressed air drill seems to be favored, especially where the work lies at some distance below the surface. The steam remains and interferes with ventilation, besides producing dampness. If we exclude wear and tear on machinery the expense of machine drilling is about one-half that of hand work.

In blasting, dynamite containing 35 per cent. nitroglycerine is employed. As to removal of débris, there appears to be nothing worthy of much remark. The expense of operating a mica mine will, of course, vary greatly with the size, location and other conditions. However, an interesting typical case is cited by F. Cirkel. Sixty tons of rock was a daily average. This was hoisted and the mica was recovered at a daily expense of $47.65. The production of thumb-trimmed mica was 600 pounds. Other expenses—such as management—must be added. Taking these into account, one ton of sheet mica cost $179, or $0.0895 per pound. However, this is not quite the total cost, as the cost of prospecting

and the like should be added. The opinion, about 1905, seemed to be that a mica mine in order to be a paying undertaking, would have to be rich enough to yield about 750 pounds of thumb-trimmed mica for every 100 tons of rock removed, for a mine operated by the quarry method; and about 1,250 pounds of trimmed mica if the mine is worked by the underground method. If the depth of the workings were over 300 feet, then the underground mine would have to be richer still in mica. Of course, these matters depend upon the price of mica at the time.

Mica occurs in the crystal in thin laminations. Formerly, only the comparatively large sizes—those ranging upward from 2×4 inches—were sought. All this is changed to-day. The smaller sizes are now most in demand—that is, sizes down to 1×3 inches. In recovering and preparing the mica sheets, the rock which may be found adhering to the mica is cleared away and the more perfect pieces are split up into sheets perhaps one-sixteenth of an inch thick. A knife whose point is sharpened on both edges is used for this purpose. The workman will endeavor to split his mica in such way as to get rid of damaged sheets and foreign matter. The edges are thumb-trimmed. This splitting and trimming are, however, only preparatory operations. At the trimming works machines are employed, especially for cutting. These machines consist of a two-armed lever. A knife edge is removably secured to one arm; an eccentric rotates beneath the other. The eccentric thus operates to make the cutting movement; a spring secures the return. These machines are electrically driven and make three cutting movements per second. In this way the edges are made fairly even. But the result is not quite perfect enough when viewed as preparatory to the fine splitting. Accordingly, one edge is ground with a fine sand. Girls now split the sheets into laminations 0.002-inch thick or even less. This is an expensive operation, since a girl can split only about ten pounds per day of the sizes 2×4 inches and less. These small sizes of extremely thin films are used in making *mica board* or *micanite*.

A kind of adhesive, shellac being one constituent, is employed in connection with building up a board out of the thin mica films. When the board has been built up, it is put under hydraulic pressure and heat is applied. The adhesive is thus dried out. Sometimes tissue paper is used in connection with the building up operation.

The small pieces of mica—those, for example, resulting from trimming operations—are by no means discarded. Such mica is largely ground to quite fine sizes. Indeed, mica is ground to a size small enough to pass a screen having 200 meshes per inch. The applications of ground mica are made in connection with the manufacture of wall papers, lubricants and fancy paints. Ground mica is also used in moulded forms as insulation in electrical apparatus. Wall papers treated with mica have a lustrous appearance.

The pulverization of mica is accomplished by machinery. The ordinary machines have a capacity of perhaps 300 or 400 pounds per day. However, there is an apparatus used in Colorado which greatly excels this output. The waste mica from the mines is first cut into small pieces half an inch on a side. This mica is conveyed by pneumatic means to the atomizers, where it is finely pulverized. It seems that the velocity of the bits of mica through the pneumatic tubes is quite high—as high as about 190 miles per hour. The atomizer consists of a shell in which revolve two shafts three feet in length. Beaters are helically arranged on these shafts in such way that the arms of the one shaft alternate with those of the other. When these shafts with their beaters of gun metal run at 5,000 or 7,000 revolutions per minute a pulverizing action is set up which effects a real comminution of the mica. The mica flour continues under pneumatic

influence to the sizing bins. The speed is reduced by a mechanical device, and the small bits fall, in accordance with their sizes, into six compartments.

Of the uses to which sheet mica is put, an interesting example is afforded by a kind of spectacles. Men working in various occupations have their eyes endangered by flying bits of stone, steel, etc. Thus the eyes of workers in stone are especially imperiled. Ordinary glass is so brittle that it cannot be used to advantage. Breakage would occur not only when in actual use, but between times. Similar remarks apply to the use of ordinary glass by steel workers. German mica spectacles are made, however, which are well-nigh indestructible. The thickness of the mica is about 1/25 inch. Hammer blows, even, do not seem to affect the mica seriously. Exposures to pretty high temperatures can also be made with impunity. Mica is often very transparent to light, but it resists the passage of radiant heat. It has consequently been found to be well suited as a cover for the peepholes in furnaces, etc. It is an admirable substance for the glazing of anthracite and gas-asbestos stoves. A miner's lamp has been constructed with mica. Two metal rings are placed at top and bottom. These are provided with annular grooves on the sides facing each other. Two cylindrical shells of mica are set, each in a pair of corresponding grooves. Red-lead cement makes the joints air-tight. The vertical joints are made in metal. A thin cylindrical shell is between the mica shells. The vertical seams are placed in the same radial plane to minimize the interference with the passage of light. We have thus an indestructible lantern. As a lamp it is not the equal of a lantern provided with glass screens, but it would seem to be incomparably safer. Mats made of waste mica are employed as boiler coverings. A cover will consist of a number of sections secured to the boiler by hooks and bands of iron. A mat consists of a galvanized wire netting in which corrugated plates of very thin mica are arranged. By the use of thin flakes a great total of surface area is secured, and the heat insulation made excellent. Experience has shown that such mats are quite durable, in spite of the alternations of heat and cold. Steam and hot water pipes are also covered with mica mats. A few years back the Canadian Pacific Railway experimented with a number of materials for the heat insulation of boilers. Tanks of cubical form and about 14 inches on an edge were filled with water, which was brought to the boiling point and then permitted to cool. Coverings or protections of mica, asbestos compound, wood lagging with air space, asbestos and wood, and magnesia blocks were all tried. Mica proved itself much better than any of the others. Thus, an unprotected tank lost 84 degrees Fahrenheit in five hours, while the mica-covered tank lost only 20 degrees. The best of the other covers permitted a loss of 30 degrees. Prof. Capper made a series of similar experiments with steam piping. A mica covering 1.6 inches thick reduced the heat loss shown by the condensation of 1.516 pounds of steam per square foot of area to that shown by the condensation of only 0.177 pound. Three other coverings were experimented with, but 0.208 pound per square foot was the lowest condensation. The thicknesses of these other coverings varied from 1.4 to 1.6 inches. Another test was made by the Grand Trunk Railway (Canada) with five locomotives. The boilers were left bare, covered with standard wood and asbestos paper, sectional magnesia blocks, silicate cloth and mica. Taking the weight of the water in the boiler as 7,000 pounds and disregarding the absorption of heat by the metal of the boiler, we find that heat losses of the first hour were, if expressed in British thermal units, 231,000, 73,500, 46,900, 77,000, 21,400. We have here evidence very favorable to mica as a heat insulator. The foregoing instances were referred to by *Engineering* some years ago.

LOOKING FORWARD

EDITORIAL NOTES ON IMPENDING DEVELOPMENTS

A Piece of Perforated Paper

About a hundred years ago an ingenious Frenchman, Joseph Marie Jacquard, invented the loom which bears his name, and in which perforated cards controlled the movements in such a manner that predetermined patterns were woven, independently of the skill of the operator. His reward was a small pension from Napoleon, a narrow escape from a mob, and the posthumous honour of a statue in the city of Lyons, the place which profited most by his ingenuity.

The principle applied by Jacquard, that of using perforations in a flexible material to control the movements of other parts of a mechanism, is probably one of the most far-reaching in its possibilities; but, with the exception of a certain class of weaving machinery, it has been but little applied until very recently, and then in a wholly different department of activity. The modern mechanical piano-playing machine, under whatever name, is practically nothing more than a Jacquard machine for weaving sounds instead of threads, and, as such, it is far more highly perfected than its textile predecessor.

It is a matter for much surprise that this extremely fertile apparatus has not been applied far more extensively to the operation of machinery of all sorts than at present appears, especially since the general introduction of electricity has made it possible to extend that control over distances and apparatus far greater than was possible when it was first devised.

The entire modern tendency in mechanical operations appears, not only in the substitution of machinery for manual operations wherever possible, but also in the planning of the manipulation by others than those by whom the work is done. The use of planning departments, functional foremen, instruction cards, and similar preliminaries to the actual performance of the work, is being generally discussed and occasionally applied; but with the exception of certain forms of tabulating machines and typesetters, and of such devices as moving electrical signs, there seems to be little employment made of the most complete method of recording and controlling movements—that of a piece of perforated paper.

It seems entirely within reason to state that no machining operation is so complicated or involves so many movements, so variously timed, as appears in the performance of even a simple musical composition by a mechanical piano-player; and when we consider the accuracy and effectiveness with which the most elaborate compositions are rendered by such machines the applicability of the method to repetition processes in manufacturing seems worthy of consideration.

In this respect a piece of perforated paper, such as the roll used in a piano-playing machine, represents simply an improved method of recording a sequence of actions. Our ordinary system of musical notation was devised originally for use with the human voice, and was intended to present the matter to the eye. The same is true of written instructions, the operator being obliged to use the eye to perceive the writing, the action

being transmitted through the muscles to the work, either directly or through the medium of a machine.

If, however, we simply substitute for visible marks on a piece of paper a series of perforations in a continuous strip, we place the instructions in a form in which they may be communicated directly to the machine without any human intervention, just as the piano is played by an untrained person, or even entirely by mechanical means.

The number of operations which may be controlled for any one machine is by no means limited, any more than the number of different musical compositions is limited for any piano equipped for use with the perforated roll. In this respect the perforated strip has an immense advantage over other forms of mechanical control, such as by cams, pins, or other devices, as will be seen if comparison is made between the strip of perforated paper and the fixed system of pins upon the cylinder of a musical box. The unlimited possibilities of the Jacquard principle over any other thus constitutes one of its greatest advantages. Any change or modification in a series of operations with the paper strip may be made simply by preparing a different set of perforations, just as one written order of instructions supersedes another; and thus it appears that a form of control in which instructions are positively combined with their execution is available for the most intricate manufacturing operations.

The impending use of such methods in the operation of machinery seems to be indicated by the general tendency to dispense with human attendance in other departments of work, and the widespread use of all kinds of vending machines, extending even to the commercial introduction of automatic restaurants, may be cited as furnishing examples of the manner in which mechanical appliances are being used to replace certain kinds of labour which are becoming either too difficult to obtain or too expensive for the operation to bear.

Apart from questions of cost, however, the nature of the control possible with the perforated strip makes it especially desirable for certain operations, even where the presence of an attendant is added. The ease with which a performer at the mechanically operated piano can vary the speed, the force of blow and the general control of the performance without being required to master the technique of the actual production indicates the possibilities obtainable along similar lines in the operation of any kind of machinery. It would seem that in nearly every operation in which the various functions are repeated according to a predetermined sequence some such device becomes applicable.

The far-reaching effects of the general adoption of the perforated strip for the control of machinery will be perceived as the subject is examined in the light of the results already obtained in connection with musical instruments. The acquisition of a correct and facile technique upon such an instrument as the piano requires intense application and years of hard work by those who have in the first place a natural talent for the subject, and of all the pupils who make such studies but few attain anything like such precision and accuracy as are given immediately to the inexperienced operator upon the mechanically controlled instrument. The real difference between the performance of a virtuoso and the effect of the machine appears only in such delicacies of expression as are perceptible mainly to the trained listener, and differences such as these are not only imperceptible but undesirable in applying the principle to machine-shop work.

It follows that the development of the perforated strip to the control of machine tools may work a change in technical training and apprenticeship methods similar to that which is be-

ing effected in the subject of pianoforte instruction, leaving the education of the mechanic to be directed to those general and varied features which include the exercise of judgment and discretion rather than of detailed and repetitive manipulation. This is entirely in accordance with the changes which have already taken place, and it is necessary only to look back over the development of the machinist's trade to perceive the manner in which the once important operations of chasing, filing, chipping, fitting, etc., have been replaced by the work of the slide rest, the grinding machine, the shaper and the drop press.

Not only in the control of machining work, but also in the direction of larger operations, may the possibilities of the perforated strip be indicated. With the introduction of electric propulsion upon railways, it may become practicable to have the trains controlled wholly from fixed stations, the motors responding entirely to the movement of the strip through a transmitting mechanism. Thus the position of a train upon a section might be made to correspond at all times to the relative position of its controlling strip, the control, both as to position and rate of speed, being always kept in the hands of the operator at the fixed station, himself continually in possession of information about all other trains upon the division. Wherever a wire can be run, such a control may be extended, so that operations at points far distant might be synchronized in accordance with any desired plan.

The outcome of such a development would probably involve, as a matter for general instruction, the art of recording instructions by preparing such controlling strips, just as the introduction of the typewriting machine has developed an art supplementing that of ordinary handwriting. The manager, director, foreman, or other responsible individual, may thus give his order, not by scribbling a few marks upon an order slip, but by punching a few holes in a card, which then becomes the medium by which the order is executed, without any of the opportunities for failure which must ever be present when it has to be filtered through various intelligences of uncertain capacity.

It is probable that such applications of the perforated strip of paper will come, not all at once, but gradually, as its capabilities are perceived; but the tendency must be, as in all other departments of mechanical developments, to relieve human effort more and more from work which is of a mechanical and routine character, reserving it for things which include the exercise of varied intelligence and judgment.

Architectural Precedents

There is a story told of a man who, having determined to build a residence, said that he thought he would erect the building himself and then have a man come and "put some architecture on it." However grotesque this point of view may be, there is yet in it a germ of common sense which may be worthy of consideration.

It is too often the case, especially with public buildings, that the reverse method obtains; the architectural elements, considered from the artistic viewpoint, control the entire design and construction, and the actual service of the building is obliged to conform itself to its housing as best it can, usually by making modifications in details from time to time under the pressure of inconvenience.

Without desiring in any way that beauty should be displaced by bare utilitarianism, it may be suggested that true beauty in any structure is largely dependent upon the association of the design with its principles of construction, and that the construction itself necessarily arises out of the purposes to which the building is to be applied. In many cases, however, buildings intended for modern purposes are designed along

lines suggested by uses which have become obsolete, or have dropped out altogether, and are thus as inappropriate in appearance and use as would be clothing of the styles of a former generation.

An excellent example of the manner in which the design and construction of a building have lagged behind its entire purpose appears in most of the buildings of recent erection intended for library purposes.

When the ability to read was limited to a few individuals in the community, and when libraries were principally formed in connection with ecclesiastical and educational institutions, it was natural that the buildings in which they were housed should be of a character similar to those by which they were surrounded. The desire to keep the books in a secluded and rather isolated place was wholly reasonable under such circumstances, and this tendency is seen even at the present time in the rather monastic influence which appears in nearly every large library building, much room being given to corridors and vaultings, while considerable space is also devoted to paintings, decorations and various curiosities. An extreme instance of this arrangement among the great libraries of the world appears in the Vatican library at Rome, in which the magnificent hall is devoted, apparently, to the collection of rare and beautiful things which have been amassed in the course of nearly five centuries, while the books themselves are nearly all carefully housed in presses and closets, entirely out of sight. In this case the arrangement is not a matter for individual criticism, since this is really a private collection, not intended for general service; but the principle which is involved still holds a powerful influence upon the housing of libraries which are intended, in fact, for general and popular use.

The great library building of today, instead of including in its design the basic ideas which would govern any real desire to promote efficiency in the avowed work of the institution, is constructed more like a great monument, or mausoleum, beautiful to look upon, but almost repellent in its inadequacy.

Suppose, for example, that the manager of a great department store, considering the plans for a new building, to be erected upon a most valuable site, at a cost of a million dollars, should find that the design included a deep space between the street and the entrance, with several steep flights of stone steps to be surmounted before the door could be reached. Suppose, further, that he should find practically the entire main floor devoted to an exhibition, in glass cases, of an historical collection of ancient costumes, while further flights of stone stairways, or infrequent, inconvenient and inadequate elevators were provided to carry those who persisted in their endeavours to proceed to an upper floor, where a portion of the more ordinary goods was placed around the walls, and where one might wait on one's self, if so inclined. Further, let it be assumed that the provision for service upon the customers was so limited as to deter rather than attract them, and that a studied absence of welcome and cordiality was included in this service, so that the visitor felt rather like an intruder than like a desired friend. Would it for a moment be believed that any considerations as to the beauty of the design, or its imposing appearance from a distance without, would be given consideration in passing upon such plans?

Let us consider for a moment the reverse method of designing a fitting house for the great public library of a metropolis. The portion rendering the greatest service to the community would apparently be that serving the great number of people who, having little time to spare from their daily avocations, yet desired to make themselves better citizens and better individuals by reading and

study. This would mean that directly upon the street level, and as conveniently and readily accessible as possible, there should be the portion containing the latest and best books upon the great questions of the day, so arranged as to be reached with a minimum of delay and inconvenience, not to the custodians, but to the users, these to be met, welcomed, and directed by persons at least as efficient as those in the great department stores of large cities. With the modern experience gained in the handling of large numbers of people and in the directing of the reading of individuals, it should be possible to plan the ground floor of such a building with sufficient adaptability to its service as to indicate the general character of the structure. When to this ground plan there were added spaces for storage and protection of books, considered with especial reference to the ready accessibility of the attendants to the standard works in greatest demand, together with more retired rooms for students and writers in proportion to their estimated numbers and importance, it will be seen that a scheme about which a suitable building could be planned would shape itself.

There is every reason to believe that such a procedure would lend itself to the production of a beautiful and imposing design to even a greater degree than any plan which failed to take into account beforehand the actual service which the building should be expected both to supply and to develop, and under such a stimulus it seems probable that the present age would produce structures worthy of comparison with those of past ages, so far as originality and absence of imitation are concerned.

There are many other kinds of buildings in which the demands of efficient usage appear to have been given scant consideration. The façade of a handsome hotel building is usually defaced by a growth of additional excrescences, such as wooden booths for cab starters, awnings or shelters for arriving guests, elevators for handling baggage and merchandise, storm doors, and similar necessities, all of which might well have been provided for in the original design and made subjects for intelligent and artistic treatment. Buildings in which the relations of the public with the government are most directly conducted are usually planned with utter absence of ideas as to efficient use, although it seems probable that an improvement in this direction is coming in some of the more recent structures.

A general study of the really great buildings of past periods—buildings which have served as precedents for many subsequent imitators—will reveal the fact that, so far from being imitations themselves of preceding works, they have grown out of local conditions and usages with distinct consideration of the service to be rendered. There was never so great an opportunity as now for original designers to follow this principle, while avoiding the servile imitation of obsolete motives, and never so clear a field for the original artist in architecture.

Efficiency and Co-ordination

Among the various elements which go to make up "inefficiency" there is probably no one more influential than lack of co-ordination. Many people and many enterprises, working toward a common end, and honestly desiring to unite their efforts, may very often be seen acting at what has been termed "cross purposes," simply because there has been no general plan arranged for their concerted action. Such lack of co-ordination generally arises more from oversight than from necessity, although it is sometimes difficult to assure men of ability and capacity that such unity of action is desirable.

When combinations have been formed to unite hitherto opposing

elements in business or manufacture one of the principal arguments offered has been the increased efficiency arising from the removal of such a defective scheme of action, and this principle is one which should be taken into account in all discussions relating to the effects of competition.

Even when there is no direct opposition or interference in operation, the mere failure to connect, so to speak, may create distinct reduction in the efficiency of the work. Everyone knows how great advantages result in travel when certain railways arrange close connections between trains, while the inefficiency caused by useless waiting at stations where such connections cannot be made needs no comment.

Not only in operative work, but in construction, the immense advantages of co-ordination appear. Two examples of contrasting methods in this respect appear in the plans adopted by Paris and New York in the construction of underground passenger railways. In Paris the whole city was first planned out with regard to routes and connections, the Metropolitan, as it is called, being intended to serve the place according to a carefully predetermined system. This plan, however, was so arranged that it might be constructed in sections, each of which, while forming a portion of the whole, could be operated effectively as soon as it was built. The several sections also were so arranged that as soon as each was completed it became an operative portion of all that had previously been constructed, so that there was complete co-ordination of the entire undertaking in all its parts. In New York, on the contrary, such a plan, although suggested, was not carried out. The result was the completion of a single unit subway, followed at a later date by plans for a second system, and this doubtless to be followed by others as yet unplanned. At the same time, main-line railways have been constructing independent tunnels, while a wholly separate system of underground electric traction has been built and placed in operation between New York and New Jersey. This lack of co-ordination in the case of New York has doubtless resulted in material increase in cost during construction, and must conduce to continual lack of efficiency in later operation.

There is now before the country a great piece of work yet to be undertaken, one the magnitude of which can hardly be estimated and the importance of which cannot be exaggerated—the construction of really good highways suitable for motor vehicles, both for individuals and for merchandise. Some of this work has been done, some of it is already planned, and much more of it is being talked about. So far, each State appears to consider the good roads movement as a local question, and in some respects this is as it should be. It is most desirable, however, that the work of the various States should be co-ordinated in such a manner that the roads built in one State should connect directly with those of adjoining States, and that, in general, a broadly planned system of highways for the entire country should be arranged, even though the execution of all the parts must be a number of years ahead. This does not necessarily mean that the work should become a national project, as that is a matter which need have no particular bearing upon the plan. It does mean, however, that there should be some general scheme upon which each State should work for its own portion, so that the highway system of the whole country would gradually be built up in the form of a complete network of roads of similar character and of maximum efficiency, both as regards the development of the surface of the State in which each portion lies and of the development of that inter-State traffic which interests every individual traversing the country.

There is probably no detail upon the advancement of which the country depends at the present time more than that of efficient transport. A road system, to be wholly efficient, should be co-ordinated, not only with all of its own parts in the various States, but also with existing systems of railway and river transport, so that those portions now isolated should be brought into immediate communication with outlets and inlets for business. Such connections, instead of being spurs or self-contained routes, should at the same time be planned to form portions of larger highway systems capable of continual development and completion by the ordinary action of natural growth. Under such an idea, planned immediately, as a whole, even though executed in separated and even isolated portions, the construction, the immediate service and the final achievement of the work would be efficient to a degree not otherwise possible. This is but a single example of the relation of co-ordination to efficiency, but it is the biggest example now in sight, and the example which is nearest in the immediate and urgent future.

The Time Fallacy

There is a disposition among many men to choose, arbitrarily, certain standards by which to measure other things without taking serious trouble to ascertain whether or not the two things compared are really commensurable. Most men would hesitate to make a direct comparison between such different things as hours and pounds, or miles and quarts, and yet it seems as if there is no hesitation whatever in assuming that all kinds of things may be measured in comparison with the *time* required for their production, regardless of the well-known fact that a very valuable thing may be produced in a comparatively short time, while something upon which much time has been honestly spent may be of very little value.

This fallacy involved in the use of time as a measure of value is the more curious in view of the fact that the time unit has tacitly been accepted by the great majority of men in all parts of the world as the proper way for determining wages for working men in a great variety of occupations; so that, as a matter of fact, the greater proportion of the population of the world receives its compensation for effort upon a basis which has little or nothing to do with the facts in the case, while by far the smaller portion endeavours to apply the product of labour on the basis of its use value while paying for it upon a wholly fallacious time measure of cost.

Mr. John Richards, than whom no man is better qualified to speak, if experience as workman, engineer, employer and philosopher is to be considered, says in this connection:

"Time work, wherein the workman is paid for a term of service, yet the most common form of employment, stands next to slavery. Not near to it, perhaps, but next in the movement toward responsibility, and is practicable only because of a sense of personal honour and justice due to the high degree of civilization existing in countries where skilled industries are carried on. Workmen, under this system, are responsible, so far as their sense of honour and emulative pride produces responsibility, but no farther. A man is hired by the hour, day, week or month, but the contract is indeterminate. If he spoils his work, or fails to render such service as common custom demands, he can be discharged, but nothing more. If he spoils work or fails by incompetence to earn his wages and a profit for his employer, it makes no difference—the law will give him his wages, irrespective of everything but willful negligence and the malicious destruction of his employer's property.

"What a remarkable compliment to the integrity and good faith of

the skilled workman of our time! Contrast it with the usages of common trade! If exchanges were to the same extent based on good faith and manly honour, would a like result follow? I am not claiming that faithful service is always rendered from honourable and unselfish motives. The penalty of discharge is always present, and the sentiments engendered by unions or trade organizations are often independent of any interest in employers or of community outside of the union; but we can only wonder that the circumstances are not worse, when the nature and manner of controlling service by time pay are considered."

The persistence of the use of time as a measure of service rendered is an indication of the necessity of looking forward in the matter of the management of labour, if any progress in this respect is to be expected. When, in earlier ages, human labour in the fields was fairly measured by time, and that much-abused unit—a "day's work"—was about the same for all men, there may have been some crude reason for using time as a measure of payment; but there is the highest authority for the statement that about two thousand years ago the use of the day as a basis for payment was considered inadequate, and with the changes which have occurred since that time the reasons for abandoning such a primitive method have increased, both in number and weight.

In the domain of agriculture, as well as in most manufacturing industries, the part which the man bears in the conduct of the work is more and more being confined to the direction of power-actuated machinery, and in such case the productivity of the operation is measured far more by his intelligence than by the duration of time in which it is exercised. As a matter of fact, the actions upon which success most frequently depends are, in modern operations, generally of the briefest duration, and any attempt to measure their value upon a time basis would be almost grotesque, even in the eyes of the most conservative of economists. There has been probably no greater impediment to human progress than the insistence of the maintenance of this inexplicable fallacy, the use of time as a measure of the value of service rendered, involving, as it does, the assumption of the wholly unwarranted position that one thing may be measured by another with which it is neither commensurable nor comparable.

Fortifying the Canal

In a signed article in a recent issue of the *Scientific American*, the Secretary of War discusses the propriety of fortifying the Panama Canal, and concludes by indicating briefly the necessity of providing a seacoast armament, with submarine mines, for protection against a sea attack, and also the provision of field works and a mobile force of troops to protect the locks and other important utilities against an attack by land.

In view of the fact that any attack upon the Canal by a modern enemy would almost certainly be made from overhead, the inadequacy of such fortifications must strike every thoughtful man. When we remember that speeds of more than 100 miles an hour have been made through the air, that machines have been kept aloft for many hours, and that altitudes of thousands of feet have been attained, it would seem as if a third dimension should be taken into account if any reasonable protection is to be assured.

Just how the Canal is to be fortified against attack from above does not readily appear, and that is probably the reason why such a possibility is so generally ignored by military and naval men. The ostrich, which is credited with a similar method of defense, might be consulted as to the proper plan to be pursued; or, possibly the idea of some joint agreement as to neutralization of the zone by all the great powers of the world might be found an acceptable substitute.

THE DURYEA SYSTEM OF MOTOR VEHICLES

By Melville G. Crafts

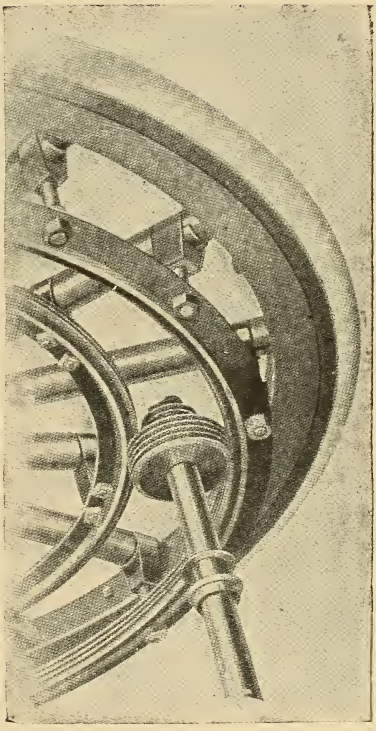
THE Duryea Motor Company of Saginaw, Michigan, is building several models of vehicles equipped with solid rubber tires which are meeting with great success both for business and pleasure, and are found to have all the virtues of that successful type of American carriage, the "buggy," which has proved itself through long use a most perfect type for the common roads found largely throughout America. The "buggy" in itself is the embodiment of generations of experience by millions of users during which every weak point has been strengthened, every ounce of surplus weight has been cut out and every improvement adopted, until it has reached the highest possible degree of perfection for the service required of them.

It is claimed for the Duryea motor vehicles that they possess all the virtues of the buggy—cheapness, lightness, simplicity and dependability, and that those who do not need great speed find in them an ideal vehicle which provides for all their wants.

The patented Roller Drive used on these cars is a radical and most important improvement. Attached to the rear wheels, close in against the spokes, are large grooved rings. Rollers, correspondingly grooved, bear against the rings and as they revolve turn the wheels.

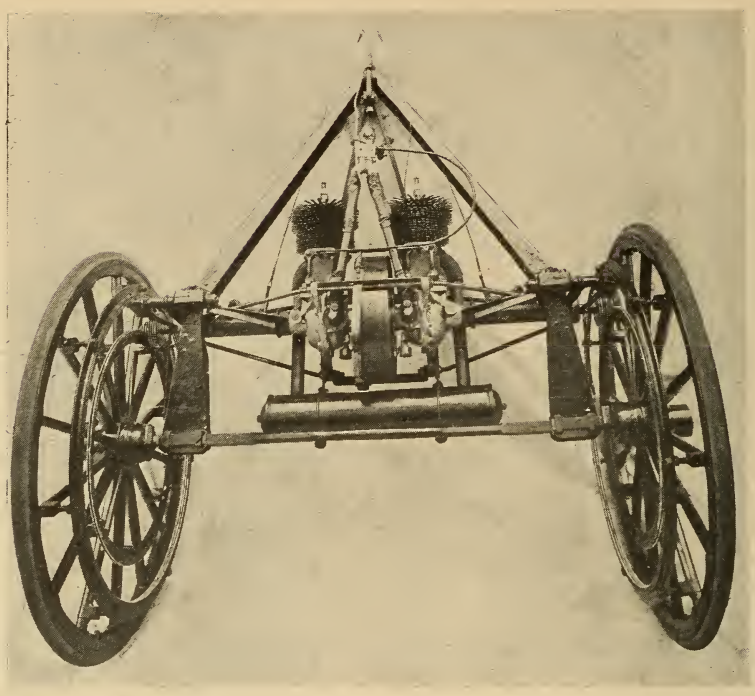
The crank shaft of the engine is parallel with the axle, and these rollers are attached to extensions of the crank shaft, reaching from wheel to wheel across the car. When the rollers are in contact with the outer ring, the car moves forward; when they bear on the inner ring, it moves backward.

The rollers are of two sizes, for high and low gear, and a simple mechanism brings either the large ones or small ones in contact with the proper rings. At "neutral," they are of course not in contact with either ring and revolve freely, without moving the vehicle.



ROLLER DRIVE OF THE DURYEA VEHICLES

The principle employed is the same as that by which the locomotive draws itself and its train of cars on the railroad track, the rollers corresponding to the driving wheels of the locomotive and the rings to the track. In the locomotive, the friction which prevents the driving wheels from slipping is due to the



TRIANGULAR FRAME OF "ELECTA." THE WHOLE POWER PLANT

weight on them. In this case, the rollers are pressed against the rings by the "change gear" lever, and the rollers and rings are grooved so that the required friction may be obtained without an inconvenient amount of pressure. In practice, on ordinary roads, the driver has to set the lever with a pressure of less than twenty pounds, which, of course, requires no effort on his part.

Four years' use of these cars with this device have shown that there is no trouble whatever in getting sufficient friction and that neither mud, sand, nor snow make the slightest trouble. This drive gives an efficiency of approximately 92 per cent., and the wear is slight, while the wearing parts can be cheaply replaced if necessary. Another advantage claimed for this system is that the weight of the motor is placed on the driving wheels, where it belongs, thus having a powerful effect in preventing skidding.

The motor used is of the perfected 2-cycle type, every stroke being a power stroke, two cylinders taking the place of four, which would otherwise be required; and as there are no cam shafts, no cam and no cam-operated valves, a great number of moving parts are eliminated.

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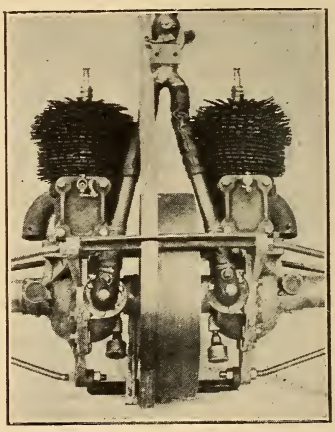


TWO-CYCLE MOTOR, SHOWING COPPER COOLING SPINES

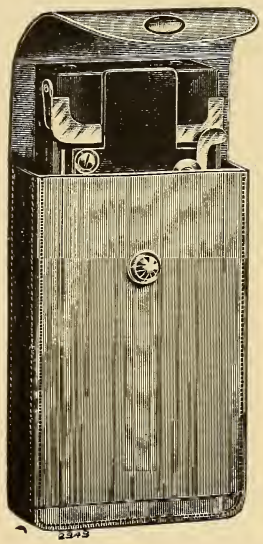
A PHOTOGRAPHIC NOTE BOOK

By O. D. Lee

AS every engineer knows by experience, the occasion often arises when it becomes necessary, or at least advisable, to insert illustrations in notes concerning investigations, reports, etc. Word-painting is all right as far as it goes, rough sketches often fail to convey all that is desired, and take time to produce satisfactorily, while even at their best they are but the draughtsman impression of the object reproduced, and may or may not be correct, while they fail to bear on their face the absolute assurance of accuracy and truth that a photograph does.

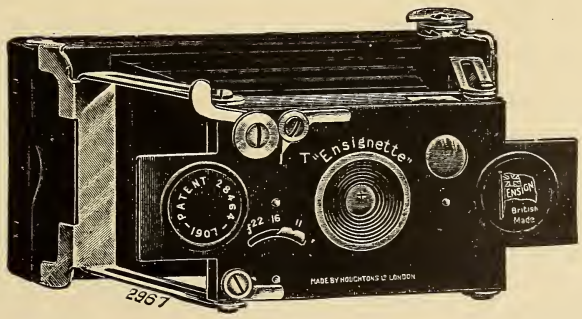
While it is true that the camera is being used more largely each year by engineers in all branches, still, up to quite a recent date, the trouble in transporting a satisfactory one, even the smallest made, has prevented its use to the extent it would otherwise have reached, while it has been found that many small cameras were neither satisfactory in their results nor absolutely reliable to do the work expected of them.

To meet the demand for a small, compact camera that would make perfect photographs there has recently been perfected and placed on the market a reliable camera so small that it can be carried in the vest pocket, thus making it available at any time and place as a photographic note-book using daylight as its pencil.



"ENSIGNETTE" VEST POCKET CAMERA IN CASE

Such a camera has been found of great service to engineers for illustrating their notes, enabling them, as



Open

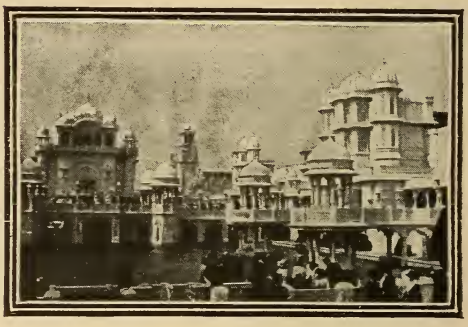
"ENSIGNETTE" VEST POCKET CAMERA OPEN

it does, to incorporate actual photographs of details of machinery, etc., whenever desired.

This camera, called the "Ensignette," when closed is 1⅞ x 3⅞ inches in size and only ¾ inch thick, yet within this small space there is compressed as perfect a little camera as could be desired, while by a new method of printing, prints 3½ x 5½ inches may be made.

Both in the beauty of its design and of the photographs that it produces the "Ensignette" is remarkable, and is proving of great service to engineers and all others who desire a compact, convenient yet perfectly reliable camera.

The "Ensignette" camera (except the leather bellows) is built throughout of non-corroding metal, oxidized black, with heavily nickeled struts and trimmings, and is in no way affected by climatic changes or conditions, thus enabling one to carry it everywhere and anywhere. It is fitted with a rapid achromatic meniscus lens with adjustable diaphragm opening, F. 11, 16, 22, which makes surprisingly sharp pictures at any distance without focusing. The shutter is automatic and requires no setting, and the image is plainly seen (as it will appear in the picture) in a brilliant view-finder set into a part of the camera itself.



ORIGINAL SIZE, MADE WITH "ENSIGNETTE" NO. 1

The "Ensignette" never fails to make good pictures, while its construction is such that it does not readily get out of order; even the film spools are made of metal, thus

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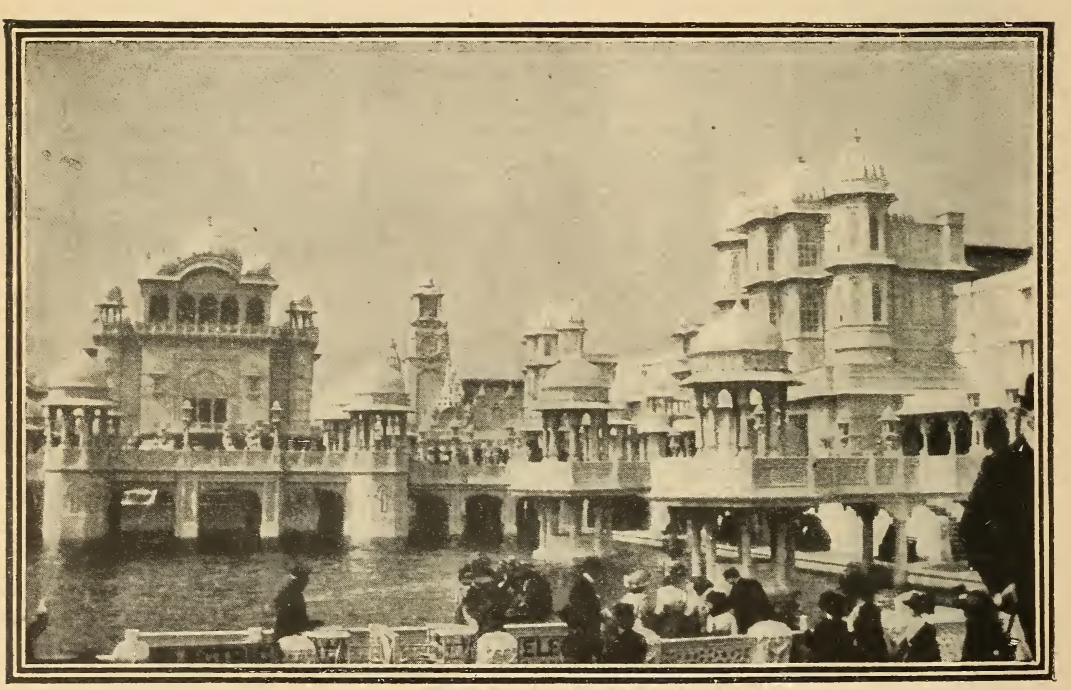

ENLARGED TO POSTAL SIZE IN "ENSIGNETTE" PRINTING BOX

REMARKABLE SPACE ECONOMY EFFECTED BY USE OF NEW TYPE OF METERS

SPACE economy is a very essential factor these days when it comes to building a plant or laying out plans for additional machinery in an existing plant. Particularly is this true in the large cities, where real estate values are high; but the advantages of saving space are always appreciated under any conditions. Any equipment, therefore, that effects this economy, while, at the same time, does not sacrifice any of its essential or advantageous features, must necessarily win for itself a place in modern power-plant construction.

No better example of this trend of modern construction has been afforded recently than by the lines of Westinghouse 7-inch diameter switchboard indicating meters, which, in the installation illustrated herewith, effected a saving of 25 per cent. in the floor space occupied by the switchboard. This switchboard illustrates a rapidly growing tendency on the part of designing engineers to economize in switchboard space by the use of meters occupying a minimum switchboard area, especially now that such meters can be obtained with a maximum scale length and readability.

This board is installed at the Mare Island Navy Yard, San Francisco, and consists of nineteen panels of blue Vermont marble. All of the panels are either 16 or 24 inches wide, obviating the use of the larger panels usually found in a board of this size.

There are sixty-three meters included in the equipment, the 16-inch panels having two meters mounted thereon in a horizontal line, and the 24-inch panels have three meters mounted in a horizontal line—a form of construction that is very desirable, and, of course, entirely impossible with larger diameter meters.

The total length of the board is 28 feet. Had the ordinary 9-inch meters been used, length would have been 25 per cent. greater, or a total

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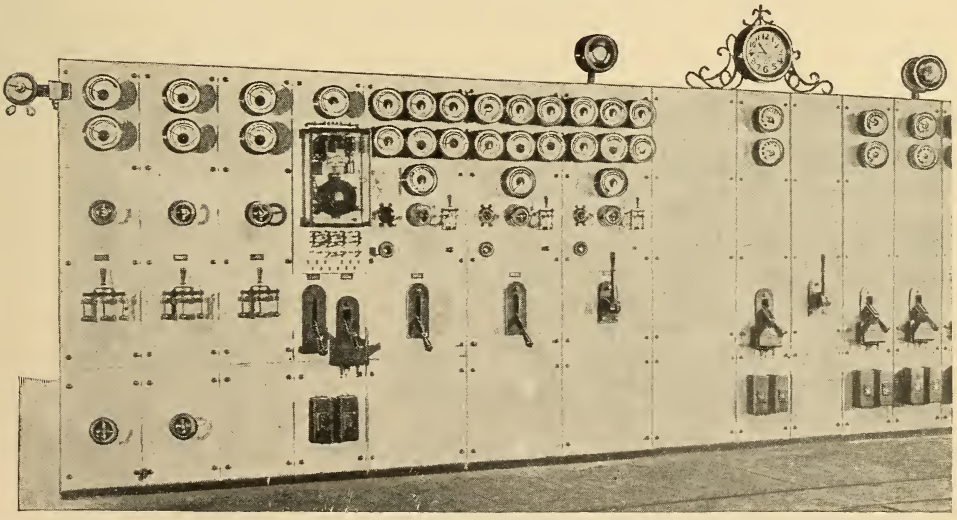


PORTION OF SWITCHBOARD, MARE ISLAND NAVY YARD

The Story of an Invention

Once upon a time the idea of a pulley was associated with a heavy, crudely proportioned round thing of cast iron, which had to be lifted upon the shaft by a derrick and supported by a scaffolding while the line shafting was being temporarily demolished to enable it to be placed somewhere in the neighborhood of the place where it could be used. It was held from slipping on the shaft by one or more set screws which acted both to mar the shaft and to force the pulley itself out of centre, and altogether the annoyances connected with its installation were such as to cause the performance to be regarded with general apprehension whenever any such job was impending. In one well-known establishment, erected many years ago, the drastic plan of fitting the entire line shaft with a continuous drum of pulleys of uniform diameter, making all speed changes by means of countershafts or by varying the driving pulleys on the machines, was adopted, but it does not appear that this solution of the question was ever repeated.

Then a very simple but far-reaching invention was made, and, like many other important inventions, it had some difficulty at first in making itself appreciated, although it has bravely outlived the early period of incredulity. By making pulleys of wood, thus at one stroke reducing weight and improving belt surface, the feature of handling was met. By making these same pulleys in halves, and providing interchangeable bushings for various shaft diameters, the question of placing immediately in position was settled. When experience with such pulleys demonstrated that they could be positively held in place against maximum belt pull, and that it was necessary only to have them thoroughly well made in order to meet all working conditions, then the revolution in pulley making was effected. The extent of this revolution will be gathered when it is stated that more than three million wooden split pulleys of the original type are in use, and that the number manufactured is increasing every year.

When the wood split pulley was first introduced, several objections were made to its use. The possibility of holding the pulley fast on the shaft by mere friction was doubted, regardless of the fact that all the power to be transmitted through it had to be communicated by the friction of a belt upon its perimeter. In this respect one is reminded of the men who maintained that no locomotive could ever draw a heavy train behind it by mere frictional contact with the rails. Again it was maintained that in matters of durability, especially in exposed situations, the wooden pulley could not replace the cast iron variety. The standard split bushing, which enabled pulleys to be kept in stock for shafting of different diameters, was looked upon by many as a crudity, and the entire device was regarded as too wide a departure from accepted practice to be of use except in certain exceptional places.

The extent to which these preconceived impressions failed to cover the facts has been shown by the manner in which the device has been accepted by engineers and manufacturers all over the world. Apart from the higher transmission efficiency of the wooden surface over that of turned iron. there is no doubt that immense economies have been effected solely by the opportunity which the general use of the split pulley has effected in the installation of machinery without disturbing existing pulleys and shafting. The loss of time and general derangement included under the old method amounted to far more than the value of the pulley, while it was often the case that the connections were made in such defective fashion as to give continual trouble thereafter.

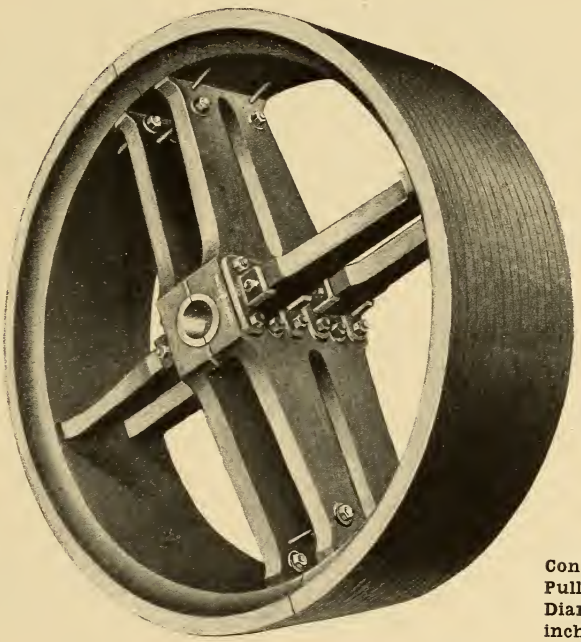
When the far-reaching value of the device is considered in connection with the simplicity of the ideas involved, it may well be conceded that the wood split pulley constituted one of the really important inventions of the nineteenth century.

DODGE

Wood Split Pulleys

JULY, 1882
INDEPENDENCE
JULY, 1912

IN SERVICE
INDEPENDENCE TRADE MARK
30 YEARS



Construction of Pulleys having a Diameter of 38 inches or more.

WHEN you buy wood split pulleys, you should be sure to get good pulleys; pulleys that will prove to be an investment, not an expense.

Dodge "Independence" are good wood split pulleys. Just as good as selected, seasoned, kiln-dried stock, combined with skilled workmanship and twenty-eight years of "knowing how" can make them.

The proof of any pulley is in the running. Dodge wood split pulleys are balanced, and run true. They are backed by the Dodge guaranty. There are over three million "Independence" wood split pulleys in successful operation and the output each year is greater than the year before.

There are reasons for this. First, the quality and merit of the pulley. The facility with which it can be mounted on the shaft. The interchangeable bushings, by means of which it fits all sizes of shafting within a wide range. The perfect shaft fastening without keys or setscrews. The superior belt surface. And last, the moderate price as compared with pulleys of any other type.

Dodge wood split pulleys will run satisfactorily anywhere that regular leather belting can be used. Complete literature on the subject for the asking.

DODGE MANUFACTURING CO.

EVERYTHING FOR THE MECHANICAL AND ECONOMICAL TRANSMISSION OF POWER

Offices and Works, Mishawaka, Indiana

Branches and Warehouses Carrying Complete Stocks

New York 21 Murray St.	**Chicago** 208-214 South Clinton St.	**Brooklyn** 37th St. and Second Ave.	**Philadelphia** 815 Arch St.	**Atlanta** 54-6 Marietta St
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Air Compressor Classes

THE capital letter class designations of the various types of air compressors, as Class A, Class G, Class O, etc., are apt to be somewhat puzzling to the uninitiated; but they mostly have not been adopted arbitrarily, and generally they stand for or suggest something of more or less importance to be remembered.

A few of these class letters are initials of descriptive words, as B for belt-driven, C for some Corliss feature, D for duplex, and so on; but besides these, and ultimately more significant than these, are the letters which mark the successive steps in the history of the air compressor, its progressive development in the direction of increased power economy, efficiency and general adaptability.

Class A stands for the type of compressors first built and now represents almost ancient history, while the other letters have been employed in alphabetical succession when radical departures in design and construction have occurred, and now O and P and their neighbours belong to the compressors of most recent type, embodying the latest and most approved features. Further along we may have Class T for turbo-compressors, which letter will then have the double embodiment of the actual initial and of the historical sequence.

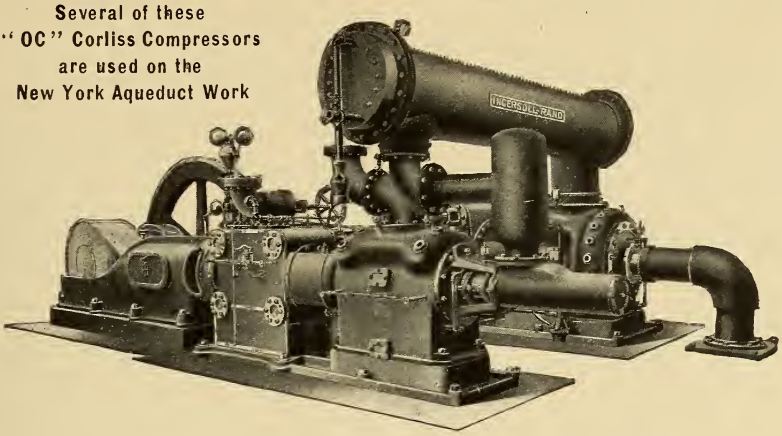
There was a time when Class A was the only type built, and when its designating letter, not being needed, had not yet been applied to it; and all concerned were, perhaps, as well satisfied with it and with its performance as now we are with the machines whose letters are approaching the other end of the alphabet. But what a distance it seems that we have traveled from our original compressor ideals! Not only have the compressors been gradually improved, the builders' ideas enlarging as their work has grown, but, most important of all, the customers have been educated, so that those who buy and use the machines require much better performance than those of old to satisfy their demands.

This has retroacted, so that while machines are still built which are nominally Class A, they are very different machines and make a much better showing than those whose successors they claim to be could ever have done. The first steam-driven compressor, which, looking backward, we now call Class A, was a plain slide-valve steam engine without cut-off or anything else, and the air cylinder, partially water-jacketed under compulsion, worked single-stage, and the machine was started and stopped by the engineer, or slowed down by hand as far as possible, according to the fluctuations of the air pressure.

The up-to-date compressor is something not only for the builder to be proud of, but for the miner or contractor to regard with good-will and satisfaction. High-pressure steam, Corliss (or equivalent) compound condensing engine, two-stage air compressing with precooling and air filtering arrangements, complete water-jacketing of cylinders, intercoolor and water eliminator between stages, aftercooler, automatic regulation of air volume according to requirements, and adjustment of power to work, reliable lubrication throughout—these are now the familiar devices of every-day practice; and it is no wonder that air compressed and delivered costs per unit of volume only a third or a quarter as much as it generally cost only twenty or twenty-five years ago.

In the operation of the steam-driven air compressor as a whole the percentages of savings are, of course, worth as much at one end of the machine as at the other; and it is a rather curious thing that, as a result of the various improvements which have developed, the actual savings in practice have been much the larger at the steam end of the machine. No strikingly novel additions to our knowledge of the properties of steam have developed; but the compressor people, builders and users alike, have finally realized that it pays to save steam in compressing air as well as elsewhere.

Several of these
"OC" Corliss Compressors
are used on the
New York Aqueduct Work



Did You Ever Stop To Think

Why it is that the contractors on the greatest engineering jobs in the country have found it to their advantage to use Ingersoll-Rand Compressors?

Here are a few examples chosen at random—the Pennsylvania R. R. North and East River Tunnels, in New York City—the New York Subway—the Catskill Aqueduct—the Hudson River Tunnels—the Belmont Tunnels—the Lookout Mountain Tunnels—the P. R. R. cut-off in Pennsylvania—the New York Barge Canal—the Lackawanna cut-off.

It is but a fair inference that these experienced contractors selected for their equipment the compressors which they knew to be the most reliable and the most economical.

Are you profiting by their experience?

NEW YORK **INGERSOLL-RAND CO.** LONDON

Offices in All Principal Cities of the World

COMPRESSORS ROCK DRILLS ELECTRIC-AIR DRILLS
CORE DRILLS PUMPS PLUG DRILLS PNEUMATIC TOOLS

Punching Holes in Armor Plate

EVER since defensive armor has been used it has been the object of the attacking party to render such protection useless. The introduction of gunpowder rendered personal armor valuable only for the museum of curiosities. The development of modern armor plate for warships, dating from the duel of the *Monitor* and the *Merrimac* in Hampton Roads in 1862, has been followed by a continual progress both in the manufacture of the defensive and the offensive elements, and the balance of success has oscillated between armor and projectile ever since.

Apart from any importance which the question may have from a military viewpoint, it is of the utmost interest to the engineer and the metallurgist, especially as regards the progress which has been made in general knowledge of the real facts in the behavior of materials under the peculiar conditions.

Thus it was once supposed that hammered or rolled plates of wrought iron would be sufficient to protect the sides of wooden vessels against the impact of the low-power guns then in use. The advent of more powerful weapons and of harder projectiles led to the development of steel armor, against which projectiles were shattered, until the further development of the guns led to cracked and ruined plates.

Thus metallurgists were led to the knowledge that a hard face and a tough back were necessities for armor plate, and various methods of surface hardening were adopted and have been perfected to secure the greatly desired combination of high resistance to perforation and great strength against cracking.

On the other hand, the manufacture of projectiles has kept pace with the development of defensive armor, until it is believed in some quarters that the story of personal armor and portable firearms is being repeated in the conflict between armor plate and guns on shipboard.

As armor plate has been improved, the requirements for armor-piercing projectiles have become continually more exacting. In order that the blow shall be given with sufficient force, the power of the gun has been increased by the use of improved explosives, while the dimensions and weight of the shot have also become greater. This means that far greater muzzle velocities than formerly are made possible, and since the striking energy increases as the square of the velocity, an enormous increase in the effect upon both projectile and armor plate is obtained. When two such bodies come in contact, and energy amounting to several thousand foot-tons must be almost instantaneously transformed, one or the other of the bodies must give way. It is expected that the projectile will be demolished, but if, in the course of this action, it pierces the armor, its function is effected. The concentrated energy imparted to it by the discharge of the gun is delivered at the point of attack, and there the work must be done.

In order to punch a hole through the plate the projectile must be hard enough at the point of impact to overcome the resistance of the hard surface of the plate; the harder of the two will be the winner. The projectile must also hold together, or its very hardness will cause it to fly to pieces and fail of complete penetration. This means that there must be a very hard front, forming an integral part of a very tough body, and when such a projectile is hurled against a plate, the hole is punched, the vessel is pierced, and the desired wound inflicted.

The latest development in the manufacture of such projectiles appears in the application of the infusion hardening process, and it is believed that with the possibilities which this method offers in the production of maximum hardness to the punching portion of the shot there will be demonstrated the superiority of this process over any which has heretofore been attempted.

Ready? Fire!!!

Armor Piercing Projectiles

made from

Open Hearth Steel

and infused with

"STELPRO"

If "STELPRO" (the Famous Hardening Compound) will stand this sort of a test—why hesitate to use it for

Dies, Punches, Gears, Milling Cutters, Etc.

Class "A" 20 cents per pound in barrel lots

CAN BE USED ALMOST INDEFINITELY

American Infusion Steel Process Company

60 BROADWAY, NEW YORK, N.Y.

Efficiency in Coal Handling

There have been many attempts to store power so that it may be held in reserve and called upon for use when desired. Some of these have been successful and others have failed to develop the great results anticipated for them, and it is interesting to observe that no artificial plans for storing energy have as yet equaled those conducted by Nature itself. When the electric storage battery was first made public, Lord Kelvin created attention by the statement of the amount of power which he could carry in his handbag from London to Edinburgh, but his statement was met by the assertion that he could carry more stored energy if he filled the bag with lumps of coal. The long train of loaded coal cars hauled along the railway represents power transmission in what is probably its most concentrated form, and in the form in which probably more power is stored and transmitted than in any other method in service.

Such being the facts, it is evident that the apparatus designed for the handling and storage of concentrated energy in the form of coal demands the highest attention of the engineer and constructor, since any lack of efficiency in such mechanism is more far-reaching and injurious than with apparatus which handles only inert stone, gravel, or similar material.

Nearly every manufacturing establishment is obliged to store fuel, both in order to be able to take advantage of the market fluctuations and also that it may be independent of any interruption in the supply. This means that the coal has to be both stored and rehandled, being received and transferred to its place in the storage yard and later picked up and passed on to be consumed in the manufacture of power.

In order that these important operations should be done efficiently it is necessary that the cost, both in money and time, should be kept at a minimum, and also that the value of the coal itself should be impaired as little as practicable.

The question of cost is closely bound up in the design of the apparatus, and it is only when very large quantities of coal have to be handled that it is found desirable to install large permanent structures, with all the equipment which is involved. For the general manufacturing establishment, some portable apparatus, capable of service over as much yard area as may be required, enables the first cost and its consequent overhead charge to be kept within reasonable limits. If such apparatus is so designed as to be operated with few men, the labor cost can be kept down, and the total cost of storing and rehandling the coal has been successfully maintained within a few cents a ton.

The matter of deterioration of coal is closely connected with the design of the apparatus by which it is handled, especially in cases of friable coals which are easily broken. The use of apparatus in which the coal is dumped over considerable distances, or in which it rolls down from an apex over previously deposited masses, is responsible for much breakage and deterioration, and when, as appears in some instances, such rough handling occurs repeatedly, the degradation may amount to as much as ten per cent., involving careful screening and regrading.

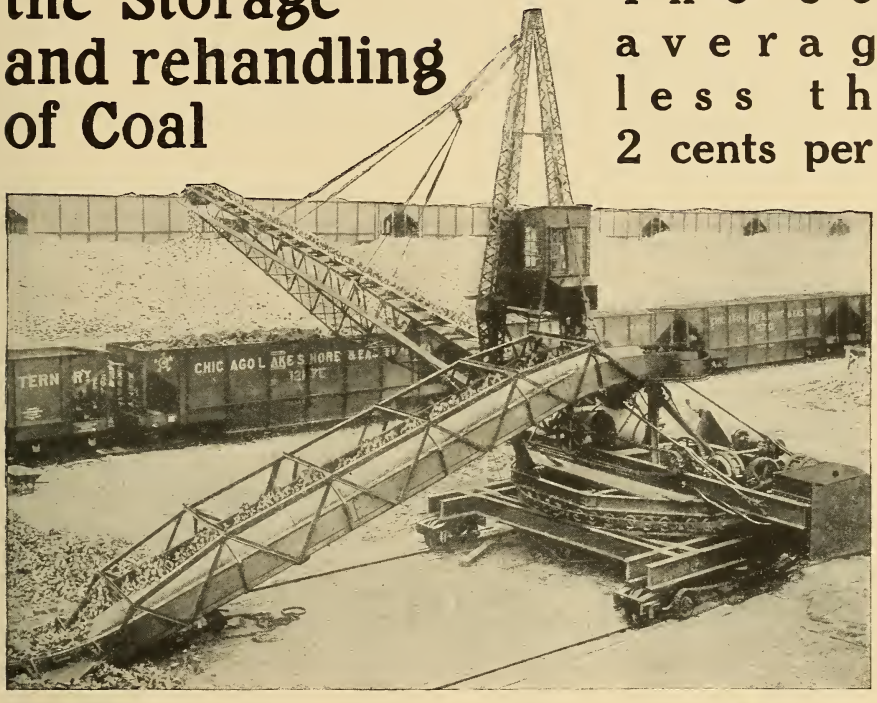
The storage of coal, considered as the storage of power, then, presents problems which do not differ greatly from other power storage systems. Questions of cost, durability, operating expense, wear and tear, and depreciation—these are the elements which should be permitted to control a decision in installing such apparatus, and when all of them are given proper weight it will sometimes be found that details of operation have more influence on the cost of handling per ton than at first appears.

Remembering always that efficiency is attained by a reduction of waste it becomes necessary only to make sure that all the wastes have been located to find out where efficiency may be raised.

Are You Considering

the Storage and rehandling of Coal

The cost averages less than 2 cents per ton



The Jeffrey-Hamilton Storage Machine

is notable for its low first cost and its simplicity and efficiency over all other machines and methods where the storing and rehandling is in thousands of tons.

Combines the Elasticity of a Locomotive Crane

with the capacity of a Traveling Bridge, but is without the limitations of either.

With this machine the coal is handled by gravity from the top of the pile—it is never drawn off under the pressure of over-lying coal.

Coal is rescreened and handled without breakage while loading

Write for additional information, prices, etc.
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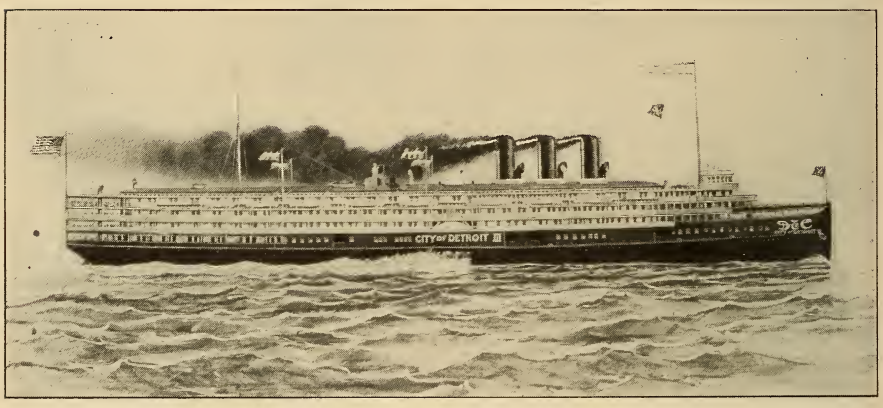
THE "CITY OF DETROIT III"

THE NEW $1,500,000 PASSENGER STEAMER OF THE DETROIT & CLEVELAND NAVIGATION COMPANY

By Cleveland Campbell



THE "CITY OF DETROIT III"

THE Detroit & Cleveland Navigation Company has recently placed in service between Detroit and Buffalo the new steamer *City of Detroit III,* which is the largest side-wheel passenger steamer in the world, and marks the epoch of finality in the shipbuilder's art and skill.

The hull dimensions of *City of Detroit III* are: Length, 500 feet over all; breadth, moulded, 55 feet; breadth over guards, 100 feet; depth, moulded, 22 feet; depth at stem, 29.25 feet; depth at stern, 25.25 feet; depth at guard, 21.25 feet. The hull is built of steel with double bottom, divided into eleven compartments by watertight cross bulkheads extending from the keel to the main deck. The bottom is divided at the centre line and athwartships into fifteen watertight tanks. There are two decks below the main deck and three above. The main deck and housings on the main deck and orlop deck are also of steel.

Her engine is of the inclined, double-expansion type, having one high-pressure and two low-pressure cylinders and three pairs of cranks. The high-pressure cylinder is between those of low-pressure and the engine. The main shaft of the engine is the largest that has ever been cast for use in a steamer on fresh water, weighing 100 tons. Although of the utmost importance, the engines do not comprise the entire mechanical equipment, each integer of which has functions just as important and essential in this way. There is a compound feed pump, sanitary, fresh-water and ballast pumps, hot draft and ventilating fans, double steam steering engines, a complete electric light plant, a combined steam capstan and windlass and four mooring engines. To furnish steam for this there are six boilers of cylindrical tube type, arranged in two separate compartments and fitted with a forced draft system. There is one single-ended boiler, 13.75 feet in diameter and 12 feet

long; one double-ended boiler of the same diameter and 23 feet long; two single-ended boilers, 14.66 feet in diameter and 12 feet long, and two double-ended boilers, 14.66 feet in diameter and 23 feet long. They are built for a working pressure of 160 pounds to the square inch.

The paddle wheels are ponderous affairs, being of the feathering type, 29 feet in diameter, each with eleven paddles, 14.5 feet long and about 5 feet wide; on the outer ends they are supported by a 14-ton steel truss.

In the building of this new steamer everything that ingenuity could suggest for the safety and convenience of passengers has been incorporated, and in her construction nothing that money could buy has been omitted in an effort to make the ship the most modern model of shipbuilding skill, combining staunchness of build with the latest approved types of mechanical equipment and every essential to the comfort and care of passengers, with palatial furnishing, fittings and decorations.

Safety has been carefully looked after and provided for. Marconi Wireless System in communication with shore and other vessels at all times while under way; lifeboats and liferafts sufficient for all regular passengers; 4,200 life preservers; automatic sprinkling system; thermostat fire alarm system, direct to captain, chief engineer and purser, indicating exact location; two fire walls; asbestos and galvanized iron lining in linen room, storeroom and on overhead freight deck; double bottom, eleven watertight compartments; fire and boat drill twice each week (men are thoroughly disciplined and drilled as to their duties in case of emergency); all machinery examined daily; powerful searchlight, rockets and most modern equipment for immediate use; patrolmen who patrol all the decks constantly—in fact, 50 per cent. more life-saving equipment than required by Government regulations.

Running hot and cold water are supplied throughout the ship; an automatic fire alarm reaches all parts; this new fire alarm, or automatic thermostat, consists of a small hollow copper wire, which is connected with a sensitive diaphragm or plate, the latter sounding the alarm. The wire is installed in staterooms and other sections of the steamer in such a manner that it is exposed so that a certain degree of heat causes it at once to sound a signal of alarm. The wire is so small that it can be placed over moulding and around fancy scroll work such as are in the staterooms. The entire boat is divided into sections, eight staterooms to a section, under the plan of the new system, and when the alarm of fire is sounded an indicator or annunciator shows in just what section of the boat the fire is. The wire is sensitive only to heat registering 140 degrees or more, and even becomes susceptible to the heat of a burning newspaper held near it. In addition to the above, fire walls have been installed, by which, in case of fire, sliding asbestos-faced doors are shoved out, confining the fire to that particular portion of the boat.

A modern ventilating system renews the air supply in all parts of the ship where such artificial circulation is required. With this new system, inside rooms are continually supplied with washed fresh air, making them as comfortable and desirable as outside staterooms.

There are 600 staterooms, 25 parlors with bath and private verandas, 50 semi-parlors with private toilets; all staterooms and parlors are supplied with hot and cold running water, washed air ventilation, also telephones with all connections necessary for shore service when the boat is at the dock. Parlors are finished in poplar and hardwood, and have a chiffonier, settee, thermos bottle for hot and cold water, electric fans and other conveniences built in place.

The lobby on the main deck is of

(Concluded on page 72.)

Investing Your Money

THE professional man and the business man have the necessary educational equipment and the practical experience to understand the conditions governing the judicious investment of money.

The science of investment is not esoteric—by reading the short, crisp, timely and reliable articles in the Investors Manual you will acquire a true sense of investment values.

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Information on industrial and other securities of value to investors and men of affairs.

OF THE

INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

DURING the greater part of the past month the controlling thought seems to have been that "if politics interfered with your business, give up your business," with the result that business generally has been quiet. The one encouraging feature, however, is that, while inactivity has prevailed, there has been no indication of depression. The strong undercurrent of confidence that has been apparent for the past twelve months continues to increase, and the consensus of opinion is that we are on the verge of a substantial revival of prosperity in all lines of trade.

It is also evident that the greatest stimulus to business will result from a satisfactory outcome of the season's crops. Thus far, reports from all sections of the country are encouraging. The mercantile business in farming communities is better than in the manufacturing centres, and reflects a hopeful and prosperous condition on the part of farmers.

In the metal market it is interesting to note that the demand for copper, both here and abroad, continues good, thus refuting, in a measure, the assertions that the rise in copper was principally due to speculative manipulation. Iron and steel mills report that they are now running at almost full capacity, and are receiving new orders sufficient to justify their continuance.

The stock market has been sluggish, with a downward tendency. Most of the trading is traceable to restless speculators, whose peculiar mental condition seems to compel them to either be "long" or "short" of the market at all times. It is generally known, however, that those who are responsible for the security market adopted a conservative policy early in April, which they propose to continue until underlying conditions in the business, financial and political world shape themselves more definitely.

The keen observer, whether he is a business man, banker or politician, realizes that the progressive sentiment in this country has assumed proportions that entitle it to respectful consideration at the hands of those who are responsible to the people, either as public officials or managerial heads of those great enterprises on which the prosperity of this country so largely depends. In view of this fact, it is surprising to note the great number of otherwise shrewd, comprehensive and capable men who refuse to recognize the irresistible determination of the people

to force a change in our methods of government, as well as in our methods of business. The individual is demanding—and rightfully so—a more direct voice in framing and administering the laws under which he has to live. The refusal to grant him these rights for no better reason than to satisfy a depraved appetite for power on the part of discredited and defeated partisans is dangerously apt to develop the "Little pitted speck in garnered fruit, which, rottening inward, slowly moulders all." Is it not, therefore, advisable for you, who are honestly striving to better the state of mankind, to look within, learn the true condition, and judge not the core by the peel, lest you be deceived?

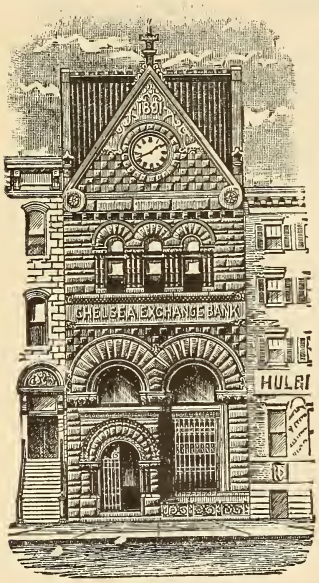
The Alberger Condenser Company, Alberger Pump Company and the Newburgh Ice Machine & Engine Company have been consolidated under one management in a new corporation to be known as the Alberger Pump & Condenser Company, with offices at 140 Cedar street, New York, N. Y.

Question—What do you think of copper stocks as investments?

Answer—There are a few good copper stocks listed on the market, which at present prices appeal to us as a profitable investment. It must be remembered, however, that in buying stocks of this character you are always taking more or less of a risk. The copper metal market is particularly strong and should have a stimulating influence on the copper stock market.

The New York Sinking Fund Commissioners have approved the plan of Dock Commissioner Tompkins for construction of two piers for ocean steamers, at an estimated cost of $8.000,000.

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

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Located at

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NEW YORK

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A Continually Growing Bank in a Continually Growing District

A stock dividend of 33⅓ per cent. has been declared by the Sharon Steel Hook Company. This is the third dividend of the kind declared by the company.

At last the Illinois Central has adopted a plan for the electrification of its line in Chicago; the work to be done within the next five years.

It is estimated that the peach crop in Georgia will reach a total of 5,000 cars, which will yield the owners about $2,500,000.

Question—How can I make a small amount safely earn a good interest return?

Answer—Providing you are not looking for an opportunity to make what is commonly called a quick turn, we would advise a good unlisted security, many of which are procurable that will pay six per cent. Securities issued against well selected New York real estate are usually dependable and can be relied upon to pay interest promptly.

The advance in the price of steel has become quite general and includes many classes; steel bars, steel plates and structural steel have been advanced $1 per ton. These advances have not come as a surprise to people who have been keeping in close touch with the situation. As compared with prices during the boom period of 1906 and 1907, the prices are from $4 to $7 a ton lower. The prevailing opinion in steel circles is that there should be still further improvement, and if nothing unusual occurs these hopes may be realized.

The President of the Canadian Northern Railway has announced that the construction program for 1912 will include 500 miles of new track in Alberta and possibly a construction of 1,300 miles to Thief's River Landing.

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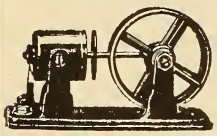
The magazine to read if you want to keep up to date on wireless and progress in electricity. With one year's subscription to Modern Electrics for a limited time only we are making the following:—



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The Technical Literature Company

144 Cedar Street :: :: New York

The Long Island Railroad has just announced through President Peters that it will run over 800 trains daily during the summer months. The latest compilation shows that there were 18,558 commuters this month, which is 2,460 more than in June, 1911. It is interesting to note that commutation travel on the Long Island Road has practically doubled in the last six years.

Question—What do you think of United States Steel common as compared with Union Pacific as an investment?

Answer—United States Steel common pays about seven per cent. on the present selling price, while Union Pacific pays less than six per cent. The speculative possibilities of the former are better than the latter. We regard Union Pacific, however, as a safer investment.

One of the most attractive investments that has been called to our attention is the six-per-cent. preferred stock issued against the Valley View Court apartments, and now being offered by the Debenture Corporation of New York. This stock is preferred both as to dividends and assets and the principal and interest are guaranteed by The Debenture Corporation of New York, and the stock is registered by The Lincoln Trust Company, Certainly, the Debenture Corporation of New York has shown its faith in the merit of the stock by guaranteeing both the principal and interest, and while the guaranteed dividend is only six per cent, it is quite possible that the stock will pay considerably more than this, as the earnings of the Valley View Court apartments are increasing, rather than decreasing. Judging from our investigations, this stock is entitled to most favorable consideration at the hands of investors.

The Duryea System of Motor Vehicles

(Concluded from page 52.)

This engine gives from 12 to 14 brake-horse-power, its nominal rating, S. A. E. formula, being about 20.

The Duryea has but ten places needing lubrication, including the four wheels, which latter need be oiled only once a year, the lubrication of the cylinders being accomplished by putting in the gasoline tank a pint of superior quality lubricating oil, called "Duryaoyl," with each five gallons of fuel. This goes in through the carburetor, and no other attention is required.

For steering and control, either a lever or a steering wheel can be used; but it has been found by experience that the former gives better results, owing to the lightness of the Duryea cars.

As to economy of fuel, in ordinary use the Duryea cars travel, on the average, from 30 to 40 miles per gallon of gasoline, while on economy test, over good roads, they have made round trips at the rate of 50 miles per gallon. The Duryea car, in good condition, will climb a 12 per cent. grade, on a good road, on high gear, with load.

Their new catalogue, recently received, describes and shows illustrations of the "Electa," a luxurious vehicle for two passengers, at a price of $750; the "Buggyaut," a light and simple vehicle, also for two passengers, at $600, and the "Surrey," a four-pasenger one, at a cost of $650.

Those who desire a serviceable and economical automobile for use on ordinary roads at a speed of about 25 miles per hour should find the vehicles manufactured by the Duryea Motor Company most satisfactory, and will be interested in this new catalogue, a copy of which they may obtain on request.

Mr. Theodore Albert, president of the William Powell Company, died at his home in Cincinnati, Ohio, May 27 last.

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Value of Mineral Output Over Twenty Million Dollars

The value of the total mineral output of Alaska in 1911 is estimated at $20,370,000, compared with $16,883,678 in 1910. The gold output in 1911 is estimated to have a value of $17,150,000; that of 1910 was $16,126,749. It is estimated that the Alaska mines produced 22,900,000 pounds of copper in 1911, valued at about $2,830,000; in 1910 their output was 4,241,689 pounds, valued at $538,695. The silver production in 1911 is estimated to have a value of $220,000, compared with $85,236 for 1910. The value of all other mineral products in 1911, including tin, marble, gypsum and coal, was about $170,000, an increase over that of 1910.

"The
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Vacuum Cleaner

collects the Dust right here in the dust bag, and doesn't scatter it about. See, the bag is nearly full of that fine Powder Dust. That's the Dangerous kind."

Let us tell you more about the Santo. It's worth your while.

KELLER MANUFACTURING CO.
DEPT. "C." PHILADELPHIA, PA.

Advantage of Hardening Steel by Use of "Stelpro"

One of the great advantages of the "Stelpro" infusion treatment of hardening steel is that the depth and extent of the hardening is absolutely under control of the operator, and steel may be hardened to any depth up to 1½ inches; further, any portion of a tool or forging can be hardened, leaving the balance absolutely normal, and the treated portions can be tempered exactly like any high-grade tool-steel.

This is only one of the advantages claimed for the infusion steel process of the American Infusion Steel Process Company, and the fact that cheap, low-carbon steels plus "Stelpro" equals better than tool-steel results at greatly decreased cost is, no doubt, responsible for the constantly growing demand for "Stelpro."

The American Infusion Steel Process Company, of 60 Broadway, New York, report many orders and much business at their milling, mixing and treating plant, located at the Bush Terminal, Brooklyn, New York.

The Steamer "City of Detroit III"

(Concluded from page 65.)

the Doric order of architecture, finished in bold-figured selected mahogany inlaid with marquetry with scagliola columns, having carved capitals with brass bases. The ceiling panels are in composition relief finished in gold. Ceiling and wall fixtures are finished in burnished antique gold, windows and doors glazed with plate and opalescent glass, and the floor of interlocking rubber tiling.

In every detail this new steamer has been well planned and carried out, and will afford passengers both comfortable and absolutely safe transportation.

A Photographic Note Book

(Concluded from page 54.)

assuring strength, yet they are so small that a supply for a thousand pictures may be carried in one corner

of a suit case, while they will keep in perfect condition from twelve to eighteen months.

There is supplied for use in connection with this camera a most ingenious developing tank, by means of which "Ensignette" films may be developed, washed and fixed in daylight, thus making the process simplicity itself; while for enlarging the small contact prints taken by the "Ensignette" there has been perfected a printing box, by use of which prints of post-card size can be made in a very simple and inexpensive manner.

This camera has been placed on the American market by G. Gennert, whose New York address is 24-26 East Thirteenth street, with Chicago salesrooms at 320 South Wabash avenue and factories at Jersey City, N. J.

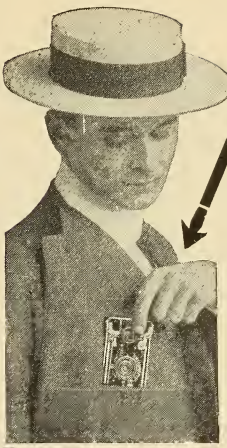
For the engineer in connection with his notes, for the doctor in illustrating his memoranda, for the tourist who enjoys preserving views of the scenes he visits, and for all who desire a small, compact, unobtrusive yet absolutely reliable camera, the "Ensignette" should prove of the greatest value and service.

A Device to Prevent Tire Punctures

Basing his theory on the principle that the carriage must be suspended upon air, Count Lieut. Soliani of Italy asserts that he has discovered a method by which pneumatic tires may be protected against puncture.

His method divides the present pneumatic tire into three small ones placed inside the wheel so as to be protected by the rim, which is of strong, unpuncturable material.

The three pneumatics act exactly as do those now in use, suffer neither from heat nor puncturing, and wear indefinitely. The Italian military authorities have examined the new method and declare it perfect, and just as speedy and comfortable as the old.



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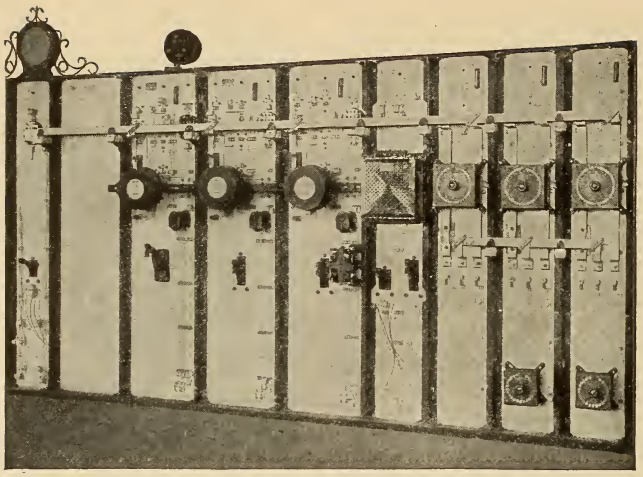
File Efficiency

It is claimed that the "Vixen" files will remove 300 to 500 per cent. more material in a given time than ordinary files. This claim is fully explained in the Report of the Committee on Science and Arts of the Franklin Institute, which the Vixen Tool Company, of 5001 Lancaster avenue, Philadelphia, Pa., has had reprinted, and a copy of which they will send on request.

Ashley & Kaufman, consulting engineers, 417 Fifth avenue, New York, have opened a permanent office at the International Amphitheatre, Union Stock Yards, Chicago, Ill. This firm have recently been retained as consulting engineers on the heating, lighting and sanitary engineers for the Union Stock Yards and the central manufacturing district, and will be glad to have manufacturers send them their catalogues and other literature to their Chicago address.



REAR VIEW OF SWITCHBOARD INSTALLATION, MARE ISLAND NAVY YARD

Space Economy by Use of New Type of Meters

(Concluded from page 55.)

of 35 feet, involving, consequently, greater expense and floor space.

The use of the smaller meters in this case meant a saving, therefore, of 7 feet of floor space, 56 square feet of marble, and much less ground to be covered by the attendant in operating the board.

The board controls two 500-kilowatt and one 1,000-kilowatt, 2,300-volt, 3-phase, 60-cycle generators with exciters. Provision is made for the future installation of a 2,000-kilowatt generator. A TA voltage generator is mounted on panel containing the control apparatus for the induction motor driving one of the two exciters.

A view of the rear of the board shows the neatness of the arrangement of wiring made possible by the use of remote control apparatus, with consequent absence of heavy wiring, bus-bars and oil circuit breakers from the back of the board.

Another point of particular interest is the mounting of the watthour meters on the back of the board, while they are very accessible and at a convenient height to be read.

The board and instruments were supplied by the Westinghouse Electric & Manufacturing Company.

Ornamental Street Lighting

A book has just been received which has been prepared under the direction of the Committee on Electric Advertising and Ornamental Street Lighting of the Commercial Section of the National Electric Light Association.

This association is exerting strong efforts to extend ornamental street lighting to every city in the United States, which is certainly a commendable ambition on their part.

The book, which is a handsomely printed and illustrated one of 50 pages, takes up very fully the important question of street lighting, the chapter headings among others being:

"The Business Side of Street Lighting."

"Lighting—Right and Wrong."

"How Business Sections Should be Lighted."

"How Residential Sections Should be Lighted."

"How Electric Signs and Window Lighting Affect the Street."

"Systems of Ornamental Street Lighting."

"What it Costs to Light a Street."

"Standards—Old and New."

And it also contains a list, alphabetically arranged, of cities throughout the United States having ornamental street lighting installations.

Ornamental street lighting is not an experiment. Three hundred cities in

the United States and Canada have tried it and approve of it; three hundred cities whose inhabitants have worked together whole-heartedly in the effort to make their streets more attractive; three hundred cities that have found that every dollar invested in an ornamental lighting system for business sections, residential districts and parks is not only returned manifold in higher real estate values and in greater prosperity, but returned in prestige, in higher city pride and in better citizenship.

To all having anything to do with the subject of street lighting we commend this publication, as they will find it most valuable. A copy may be obtained by addressing Mr. William H. Hodge, care H. M. Coyllesby & Co., Insurance Exchange Building, Chicago, Ill.

A $10,000,000 Hydro-Electric Development Planned

A group of capitalists, including, among others, Mr. Joseph R. Paull, of the Joseph R. Paull Investment Company; Mr. Joseph C. Trees and Mr. M. L. Benedum are applying for seventeen charters in that number of townships in seventeen counties for the development of water-powers and the supplying of cheap electric energy for the industries of Pittsburg, Pa. It is planned, among other things, to dam the Clarion and Tionesta rivers for power uses, these dams being built to form a reservoir or lake fifty-two miles long on the Clarion river, and the expectation is that it will be possible to supply electric energy at one-half the cost of generating it by steam.

Such dams will hold back the mountain torrents and put an end to flood menace, in addition to going far toward furnishing electric power for Pittsburg produced without coal consumption, thus reducing the smoke in that city.

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.

Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER

ALBANY, N. Y. Industrial Agent

If you are interested in concrete construction read

Concrete-Cement Age

A combination of *CONCRETE-CEMENT AGE* and *CONCRETE ENGINEERING*

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The leading journal published in the interests of the cement industry. This magazine is the standard publication in the field, carrying the latest authoritative reports of the progress made in the theory and practice of concrete engineering.

The Reliable Journal for The Engineer, Architect and Contractor

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YOU can do what others do!

You *can*—if you really want to. You can fit yourself to earn *more* than the other fellows. For they are not naturally any smarter than you. They haven't any more brains or ambition than you. They don't work any harder than you. They are simply *trained men*—that's the difference. They have *special knowledge* that you don't possess—*special knowledge* and *training* that makes them *worth more* to their employer than you can possibly be until *you* equip *yourself* with special knowledge and training.

The American School is training *hundreds* of men to become draftsmen, engineers and architects. It is training hundreds to fill executive positions, to earn *good* salaries, to play a man's part in the business game. *And what the American School of Correspondence is doing for others it can do for you.*

Mark the Coupon

and send it back to us *on the next mail.* That's the first step towards getting your name higher up on the payroll—the first step towards getting the kind of position *you'd like to have,* the kind of a salary *you ought to have.*

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American School of Correspondence, Chicago, U. S. A.
Please send me your Bulletin and advise me how I can qualify for the position marked "X." Cass. 12-'11

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.....Draftsman	.....Fire Insurance Eng'r
.....Architect	.....Telephone Expert
.....Building Contractor	.....Moving Picture Op'r
.....Structural Engineer	.....Book-keeper
.....Civil Engineer	.....Stenographer
.....Electrical Engineer	.....Accountant
.....Elec. Light & Power Supt.	.....Cost Accountant
.....Master Mechanic	.....Cert'f'd Public Acc'nt
.....Sanitary Engineer	.....Auditor
.....Steam Engineer	.....Business Manager
.....Reclamation Engineer	.....College Preparatory

NAME .....

ADDRESS .....

Steel Tanks

Catalogue No. 12, descriptive of the steel tanks manufactured by them, was recently issued by William B. Scaife & Sons Co., of Pittsburg, Pa. This work completely covers the entire field of riveted, brazed and welded tanks for every conceivable purpose, including air and gas receivers, water and oil storage tanks, hot water boilers, steel barrels, expansion tanks and gasoline storage tanks, and also contains many useful tables and a considerable amount of data connected with the construction of steel tanks and cylinders for various purposes which will be found most useful.

By addressing William B. Scaife & Sons Co., 221 First avenue, Pittsburg, Pa., a copy of this important publication may be obtained.

"Radialaxe" Air-Driven Coal Cutters

5003 is the form number of a 20-page, 6×9 bulletin, just received from Ingersoll-Rand Co., 11 Broadway, New York City, New York, descriptive of the "Radialaxe" Air-Driven Coal Cutters, as manufactured by them. These machines are especially adapted for undercutting in a pitching seam; shearing in seams (particularly entries); mining near the middle of the seam; cutting out veins or bands of fire clay or slate in the coal seam; mining under or above such seams so that the dirty material can be loaded without mixing with the coal, and driving entries or headings.

Catalogue shows the various styles of mountings required for each particular line of work, and contains several illustrations of machine at work underground. A descriptive table on the last page gives the various sizes and capacities.

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French, with or without Master, 2 vols., each . $1.00
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Four-years course leading to degree of Bachelor of Science in Mechanical Engineering. While the course is planned with special reference to mechanical engineering, much time is devoted to electrical work, and such attention is given to engineering chemistry, civil engineering and general subjects as to graduate men with broad fundamental training along engineering lines. Catalogue on application.

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THIS institution offers complete courses, each leading to the degree of E. M. (Engineer of Mines), in four different groups, viz.: I. METAL MINING; II. COAL MINING; III. METALLURGY; IV. MINING GEOLOGY; and V. A COURSE IN APPLIED CHEMISTRY leading to the degree of Ch.E. (Chemical Engineer). A postgradute course leads to the degree of M. S. (Master of Science).

The school, by reason of its situation, affords peculiar facilities for the inspection of mines and smelting works, field geology, and practical surveying.

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A Special Engineering Bulletin Mailed on Request to

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Courses are offered in Mechanical, Electrical, Civil and Chemical Engineering, Architecture, Chemistry and Biology, as well as courses in Arts and Science, Finance and Commerce. New Engineering laboratories of the most modern and approved kind and on a large scale have recently been erected.
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Organized under charter of the University of the State of New York.
Courses leading to degrees of the University, of Bachelor of Science in Chemical, Civil, Electrical and Mechanical Engineering. Four years of thorough training and resident college work.
The Clarkson Bulletin, published quarterly mailed on application.

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A new school with new building and apparatus. Twelve miles from Chicago, a centre of Engineering operations of great interest and magnitude. In close relation with College of Liberal Arts. Beautiful campus, stimulating environment of a University town.
Write for "Best Preparation for Engineering" and Book of Views.

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ESTABLISHED 1824

SCHOOL of ENGINEERING

Civil, Mechanical, Electrical

Send for a Catalogue. **TROY, N.Y.**

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The Crowd That Will Go

When the Panama Canal is finished, the few to be retained will be the experts. The crowd that will go are the 28,536 untrained workers.

No more striking example of the relative value of trained and untrained men can be found anywhere than this. Here you see exactly what happens when a large working force is to be reduced. The **trained** men **stay**—the **untrained go.**

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Sheet-Metal Draftsman	Advertising Man
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Marine Engineer	
Stationary Engineer	

*Name*_____

*Street and No.*_____

*City*_____ *State*_____

*Present Occupation*_____

Electric Heating and Cooking Appliances

Bulletin No. 4921, issued by the General Electric Company, of Schenectady, N. Y., is devoted to the above subject, and is a handsome work of 62 pages, with many fine illustrations.

As electricity is a safe, clean and easily controlled heat source, and offers numerous advantages when employed for heating and cooking purposes, this book will, no doubt, meet with a large demand.

A copy will be sent free on request.

Morrison Water-Tube Boiler

There has been received from Mr. Egbert R. Morrison, general sales agent for the Morrison water-tube boilers, a descriptive booklet of this type of boiler. The Morrison boiler is unique in the arrangement of the tubes. Not only can any tube in the entire boiler be removed without injury to any other tube, but also without the displacement of baffles or brickwork. The result is achieved by staggering the two intermediate rows in each bank with the centre row, at the same time arranging the two outer rows in a series of short and wide spaces. The wide spaces in one outer row alternate with those in the opposite outer row. The tubes in the centre row may thus be removed alternately through right and left spaces, and the tubes in the intermediate rows may all be removed through these same spaces.

The Morrison boiler is built in single, double or triple pass style and in single, double or other multiple sections—end or side-fired, depending on the location of the grates at the end or side of the drums.

A copy of this booklet may be obtained by addressing Mr. Egbert R. Morrison, Sharon, Pa.

Chucks

The new catalogue of lathe, drill and planer chucks, also reamer and assembling stands, drill press vises and face-plate jaws issued by the Skinner Chuck Company, of New Britain, Conn., is now ready, and will be sent on request.

NEW PUBLICATIONS OF THE GENERAL ELECTRIC COMPANY

Street Lighting with Edison Mazda Series Lamps

This work treats of the important subject of proper lighting for streets, and discusses it from the following scientific and economical aspects:

1. A sufficient amount of light must be supplied and so distributed as to give a uniform illumination.

2. Street lamps should have as low an intrinsic brilliancy as is compatible with economy, and be so located that any glare will not interfere with ordinary vision.

3. With the usual height and spacing, the greatest intensity of light should leave the lamp at an angle of about 20 degrees below the horizontal.

4. The light should be steady, for flickering obviously reduces the illuminating efficiency of the lamps.

5. There should be good diffusion of the light rays, so as to avoid deep shadows.

6. The lamp should be placed fairly high, thus giving more light at distant points and avoiding long, distorted shadows from objects on the roadway.

This book is full of information concerning street lighting, very fully illustrated, and should be in the hands of everyone who has to do with street illumination.

Railway Signal Volt-Ammeter

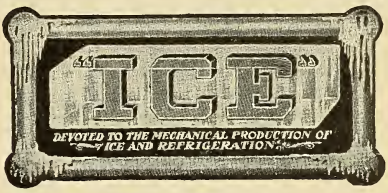
Bulletin No. 4880 is devoted to the Railway Signal Volt-Ammeter, for use in testing direct-current railway signal apparatus and doing similar work on telephones and telegraph circuits.

Type H Transformers

The General Electric Company recently issued an attractive illustrated bulletin, No. 4938, devoted to its Type H transformers. This bulletin supersedes the previous bulletin on the same subject.

Direct-Current Portable Instruments

Bulletin No. 4949, just issued by the General Electric Company, is devoted to direct-current portable in-



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Devoted to the Mechanical production of Ice and Refrigeration.

Published monthly at $1.00 per year.

The mission of this publication is to serve those interested in the operation of ice and refrigerating plants, and its readers among this class say its indispensable.

Sample Copy 10c.

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Published by the Alumni Association

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Through our Capability Exchange we can furnish **EXPERIENCED TECHNICAL MEN** for the **better** positions in any branch of Mining and Metallurgy.

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An organization of water works managers and engineers, for the improvement of public water supplies and water supply business.

The Association holds annual conventions, and publishes the Proceedings thereof.

For particulars as to membership, price of Proceedings, and other information concerning the Association

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J. M. DIVEN, Secretary

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(Pink Sheet)

Daily Bulletin

is published every working day in the year and contains the latest news about new industries started, new firms incorporated, new bank and trust companies, enlargements, increases in capital, contracts awarded, fire losses, new buildings, machinery and supplies wanted and building and construction material wanted.

The subscription price is $25.00 per year or free with every advertising contract amount to 52 or more inches yearly.

Write for sample.

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struments, Type DP—2, which are designed for laboratory and general testing purposes. This line of instruments includes ammeters, voltmeters, mil-ammeters and milli-voltmeters. The publication supersedes the company's previous one on this subject.

Standard Pumping Engines

Catalogue No. 12, issued by the Standard Pump & Engine Company, Cleveland, Ohio, is a handsome publication of 38 pages, very fully illustrated. They claim for these pumps standard simplicity and high quality, both in design and materials, believing, as they do, that to most purchasers quality is a matter of first consideration. Their standard hand pumps for suburban residence water supply, standard geared engine for use in water supply, standard junior water system, suction and lift pump, power engine, pumping engines, rotary pumps, centrifugal pump, etc., are fully described and illustrated. The book also contains many pages of useful information for pump users.

A New Type of Jackhammer

The new Type "BCR-43" Jackhammer is described and illustrated in a 12-page, 6 x 9 bulletin, form No. 4021, just issued by the Ingersoll-Rand Company, 11 Broadway, New York, N. Y.

The machine is a new series of hand hammer drill designed to operate with either steam or air for drilling down holes of average size and depth. It is automatically rotated, and equipped with the "Butterfly" valve, a simple piece of steel oscillating on a central trunnion, actuated by the mere unbalancing of pressure on each wing alternately and requiring a negligible amount of power to operate. The drill has a 2¼-inch diameter cylinder, 2-inch stroke, uses ⅞-inch hollow hexagon steel, and weighs 40 pounds.

Catalogue shows several views of drill in operation and lists sizes and prices of the hollow steels.

Keeler Water-Tube Boiler

The E. Keeler Company, of Williamsport, Pa., have recently issued a handsome catalogue descriptive of the Keeler Water-Tube Boiler. This company is in the forty-ninth year of its activity, and their water tube boiler, therefore, represents an experience of nearly fifty years in boiler construction. The book will prove of interest to steam users, and a copy may be obtained by addressing Mr. I. B. Maitland, general manager of the E. Keeler Company, and mentioning CASSIER'S MAGAZINE.

Shaking Grates

Under the title of "Save Coal" there has been issued by the Shear-Klean Grate Company a catalogue descriptive of the Shear-Klean grates, which use two motions instead of one, as is commonly used in a rocking grate, the first being that of rocking all of the grate bars and after that each alternate grate bar is shifted sideways in both directions, thus grinding and crushing the clinker above. The manufacturers claim many advantages for this grate, among these being that they will burn the kind of coal it is desired to burn and give the best results. A copy of this catalogue may be obtained by addressing the Shear-Klean Grate Company, 1652 Monadnock Building, Chicago, Ill.; the United States Engineering Company, 80 Wall Street, New York City, or Mr. Wm. P. Harley, Charleston, S. C.

Electric Fans

A handsome illustrated catalogue of electric fans has recently been issued by the Fort Wayne Electric Works of the General Electric Company, Fort Wayne, Ind. Their fans are designed for all standard voltages and frequencies and embrace all the latest improvements in oscillating devices and other important details. Special attention is called to their 8-inch oscillating fans, which permit the fan to oscillate approximately six times per minute and for which there is a constantly growing demand.

LAUGHLIN
Safety Self Filler
Fountain Pen

Cut Showing Barrell Drawn Apart Exposing Pressure Bar, Ready for Refilling

Guaranteed absolutely non-leakable—pen and feed kept moist and primed, insuring a free, uniform flow of ink instantly upon contact with writing sheet.

May be carried in any position in pocket or bag without possibility of leaking or sweating.

Every pen guaranteed satisfactory to the user or money refunded. Size illustrated in this advertisement **$2.00** by mail prepaid to any address, plain black chased or mottled as desired.

It is not necessary to write us a letter; simply pin a $2.00 bill to a slip of paper containing your name and address and we will mail the pen by return mail.

Send us the name of your dealer,

that you asked to show you a LAUGHLIN Non-leakable Self-Filling Fountain Pen, and we will send you FREE OF CHARGE one of our new Safety Pocket Fountain Pen Holders.

It is not required that you purchase a pen to get this Safety Holder. We simply want the names of dealers who do not handle this pen that we may mail them our catalogue.

We will appreciate this favor very highly.

Address,

Laughlin Mfg. Co.
797 Griswold Street
Detroit, Mich.

the safest pen for Field work is

The SECURITY Guaranteed Fountain Pen

non-leakable

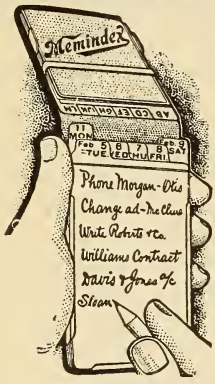
No. 3 S.Y. made with a short, heavy cap that screws down tightly over the section. 14kt. Gold Nib. Prevents any leak or overflow of ink while the pen is carried in vest or trouser pocket or traveling bag, or while lying flat on desk. They are the safest and most convenient pen made, and hold plenty of ink for ten days' use.

Sent postpaid for ten days' trial— money back if you want it. $1.50

the time saving Draughting Stylo

No. 33 This pen has a smooth point and patent needle, insuring a ready and easy flow of ink. Writes ten days without refilling. This Stylo Pen is made of the best quality pure Rubber in red or black and is manufactured in the best possible manner. This pen can be safely carried in the vest pocket or traveling bag, as it is an absolutely non-leakable Stylo Pen, and is always ready to write. "Buy a red one for red ink and a black one for black ink." $1.00 postpaid

DIAMOND POINT PEN CO., 39 to 47 West 19th St., New York



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Other styles up to $7.50.		
Sunday cards extra	.35	.50

Prices in Canada 20% more, duty paid.

WILSON MEMINDEX CO.
18 Dey St., Rochester, N. Y.

Weis Efficient Business Furniture

Your letters, catalogs, business papers stand "At Attention" —on edge—for instantaneous reference in *Weis* files.

FOUR DRAWER VERTICAL FILE

Capacity 20,000 Letters Solid Oak (Golden or Weathered)
Roller Bearings Dust proof Drawers **$13.25**

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In East and Central States.
Cabinets of less capacity at lower prices.
Get large colored cut.

Weis Compact Sections

Greatest capacity in smallest space. Made in 26 styles for every commercial requirement. Build as needed, on one or more sections. All four sides finished. Beautiful Quarter Sawed Golden Oak and Birch Mahogany.

Reasonably priced.

Weis Sectional Bookcases

Serviceable, yet ornate. Your office or home needs them. Dust Shield makes them dust proof. Patent Equalizer guides and controls Easy operating door.

CATALOG "E"—FREE—Shows Standard or Mission Styles to match your home or office furnishings. Lower in price than you think. FREE "FILING SUGGESTIONS"—This booklet helps solve filing problems. Assists in your selecting equipment from CATALOG "D"—64 pages helpful office equipment, four lines filing devices. CATALOG "E"—2 complete lines Sectional Bookcases—handsome, inexpensive.

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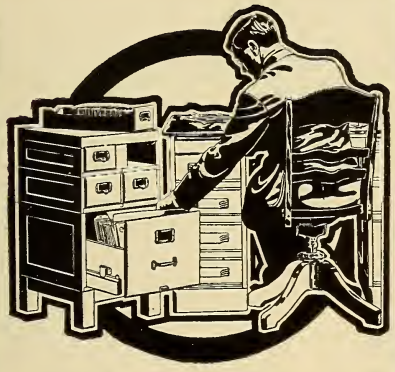

When you want Smith's letter, or a copy of Jones's order, you like to get it quick—so does every busy man.

Efficiency Filing Equipment—the **Neverstick** kind—and Shaw-Walker Systems, always simple and practical, enable you to find what you want when you want it—**Instantly.**

Scientific Management in the Office, a little booklet we have just issued, describes briefly the scope of Efficiency Methods for the Office, and points out some of the channels through which time is wasted and money lost.

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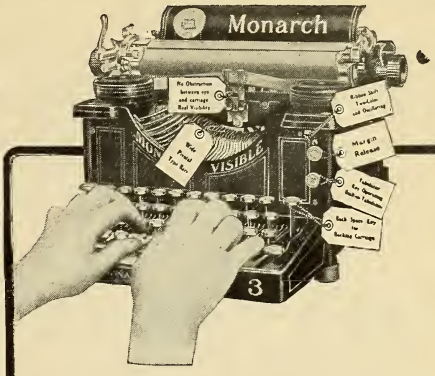

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to the points of Monarch Typewriter Excellence pointed out by the tags shown above, every owner and every operator should be keenly interested in that great typewriter advantage of the Monarch, the

Monarch *Light Touch*

which is a wonderful saver of human energy. More work and better work with greater ease is the net result of this feature of the Monarch machine.

To the operator it means "No 3-o'clock Fatigue," but steady work with ease right up to closing time. To the employer it results in more work accomplished, therefore a distinct saving.

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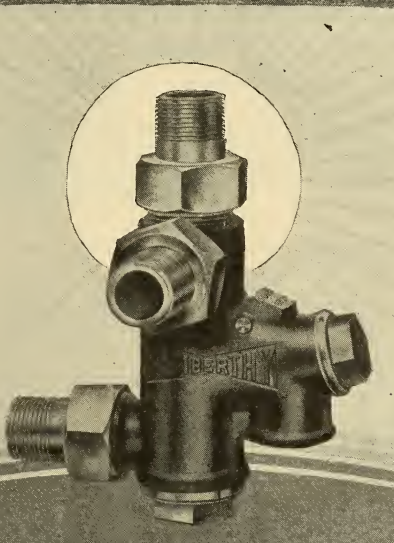

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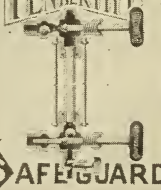

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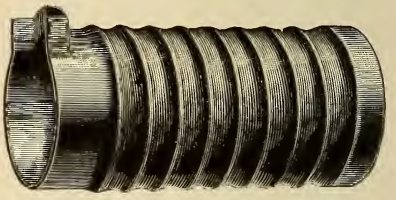

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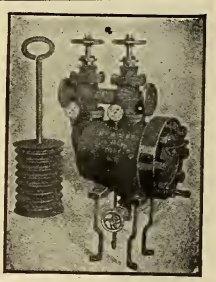

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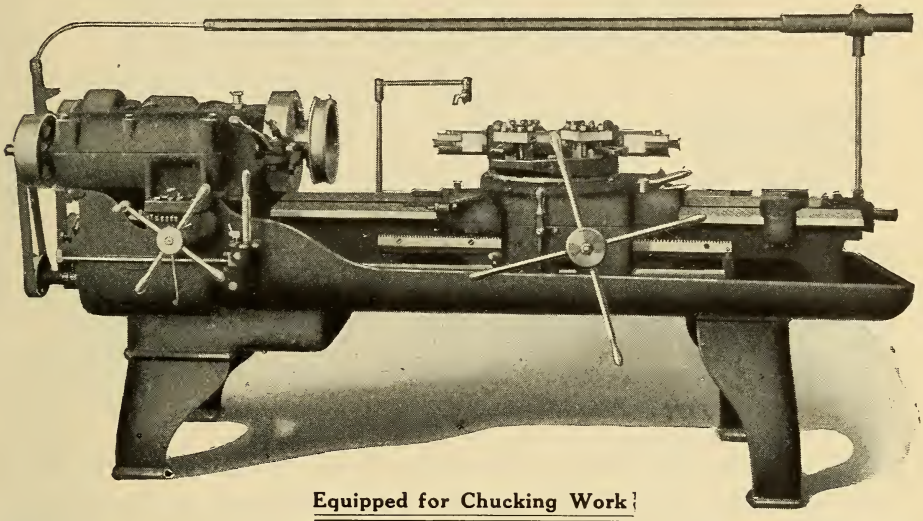

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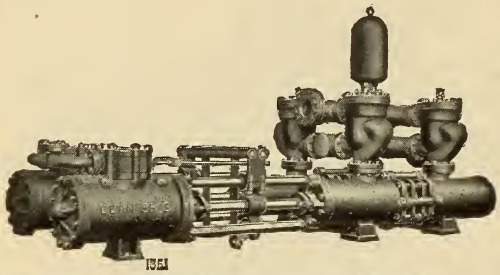

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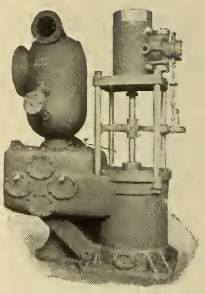

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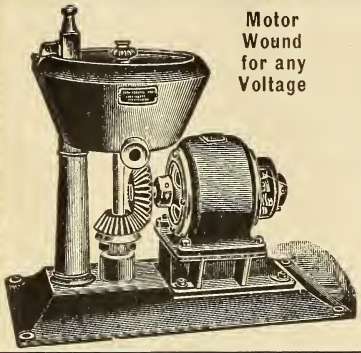

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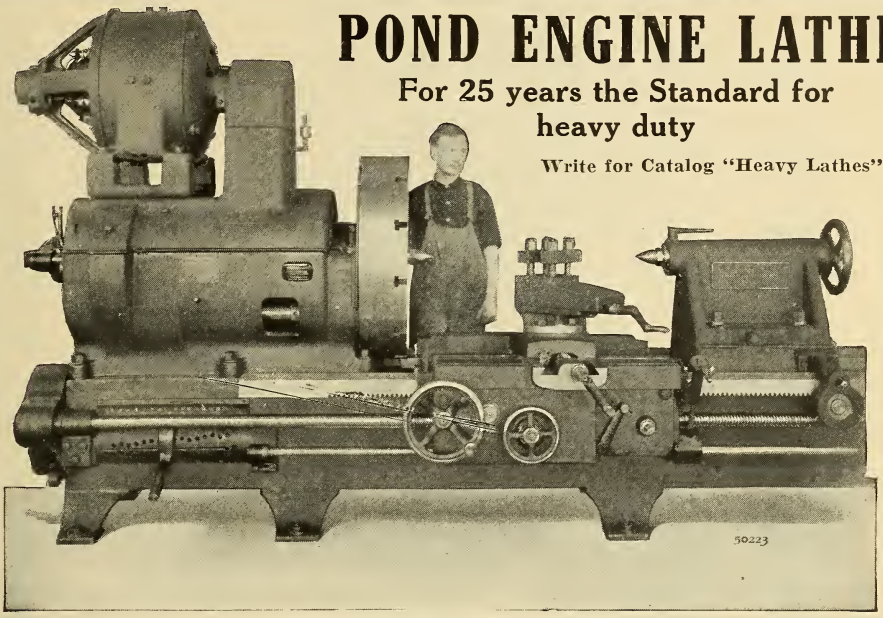

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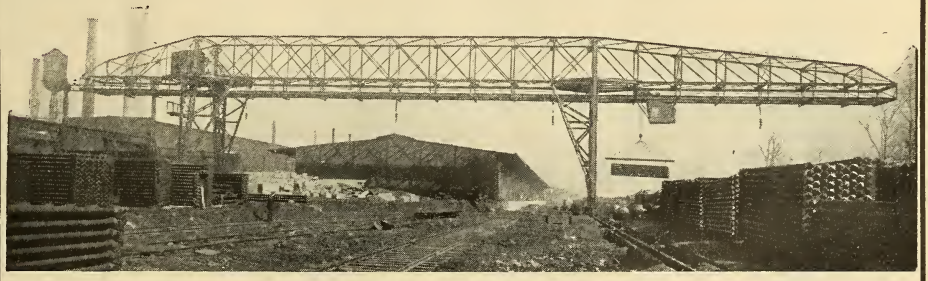

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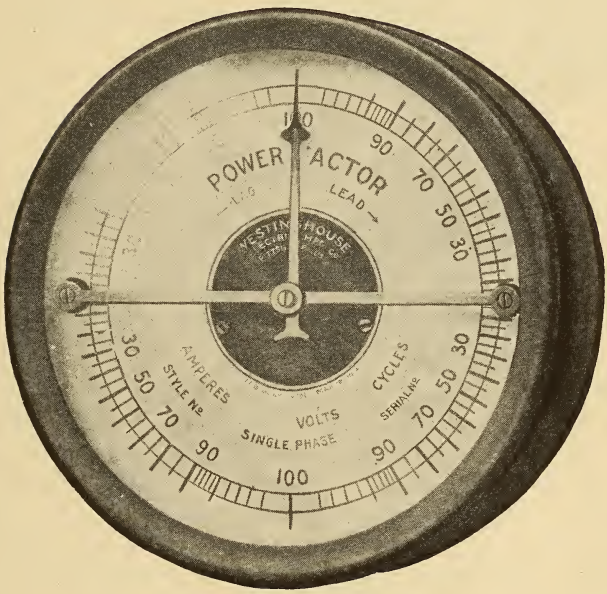
POWER FACTOR METERS



SEVEN-INCH POWER FACTOR METER

A poor powerfactor can often be improved by a better proportioning of the motors to their load, the use of a super-excited synchronous motor or similar means, with resulting increased capacity and efficiency of the system. It is therefore important, particularly in heavily loaded plants, to know what the actual powerfactor is at various conditions of load. To do this, it is not necessary, as it once was, to take readings of voltage, current and power and to calculate from these the ratio of true to apparent watts. The introduction of direct reading powerfactor meters has made calculation unnecessary and enables the determination of the powerfactor without trouble. Their use indicates whether induction motors on a system or on any circuit of a system are being properly operated, and enables the adjustment of the exciting current of synchronous apparatus to values giving the most economical powerfactor, also indicating a reversal of power if it occurs.

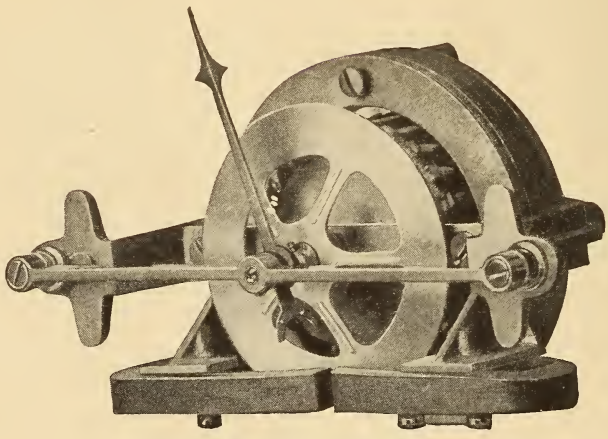
On polyphase systems supplying a mixed load, powerfactor indicators are a necessity, as the calculation of powerfactor from other meters is complicated and difficult and may give very misleading results. A polyphase powerfactor meter having current connection in each phase of the circuit will indicate the average powerfactor of all the phases.

NINE-INCH POWER FACTOR METER

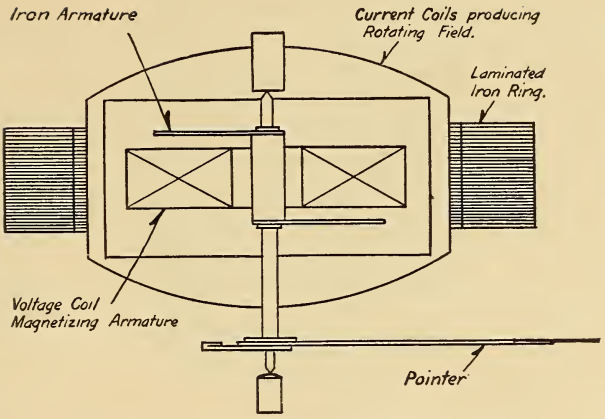
The illustrations show two types of direct reading powerfactor meters manufactured by the Westinghouse Electric & Mfg. Co. These meters indicate on a graduated scale the powerfactor in the circuit to which they are connected.

The powerfactor meter operates on the rotating field principle. A rotating field is produced by the current of the metered circuit passing through angularly placed coils. In this rotating field is situated a pivoted iron vane or armature, magnetized by a coil whose current is in phase with the voltage of one phase of the circuit. As the iron vane is attracted or repelled by the rotating field of the current coils, it will take up a position where the zero of the rotating field occurs at the same instant as the zero of its own field. Thus its position will always indicate the phase angle between the voltage and current of the circuit. The pointer attached to the armature, therefore, indicates this angle, and, by marking on the scale the cosine of the angle shown by the graduation, the powerfactor is read directly. In the three-phase meter the rotating field is produced by three current coils spaced 60 degrees apart; in the two-phase meter, by two current coils spaced 90 degrees; in the single phase meter the position of voltage and current coils is interchanged and the rotating field is produced by means of a split phase winding.

An illustration shows the movement of a type SI seven-inch powerfactor meter. The winding shown within the iron ring is the stationary winding of the current coils. Inside this, and not shown, are the stationary voltage winding and the pivoted armature. The laminated iron ring surrounding the winding is provided as a return circuit for the flux of the pivoted armature, so that the reluc-



MOVEMENT OF POWER FACTOR METER



CROSS SECTION OF POLYPHASE POWER FACTOR METER

tance of the armature magnetic circuit is low and uniform in all positions. These parts are shown in the diagrammatic cross-section.

The aluminum disk shown in the illustration at the front of the meter is a damping disk moving in the concentrated field of the two permanent magnets at the bottom of the mechanism. These magnets and disk have no effect whatever on the electrical operation of the meter. They serve to absolutely prevent oscillations of the pointer, and thus make the readings "dead-beat." The pointer, therefore, does not swing back and forth, but comes to rest at once at its correct position. More efficient damping is obtained with this electromagnetic device than is possible with air damping devices unless a delicate and easily deranged adjustment is resorted to.

It will be noted that in this form

(Continued on page 64.)

AN ILLUSTRATION ON MODERN EFFICIENCY

By O. D. Lee

Efficiency is the act or power of producing effects, and true efficiency means the power to produce desired effects at the least expenditure of time, effort and money.

It is fully as necessary to reduce the number of necessary motions or operations as the number of unnecessary ones.

The story is told of a shop manager who, in showing a visitor through the works, said: "There is a favorable example of motion study; that machine operator does not make an unnecessary motion, each one has been planned to give him the highest efficiency." "So," said the visitor, "but are you aware that there is a machine built for that work which through its design requires only one-third the motions on the operator's part your standard calls for?"

While without doubt motion study will result in lessening the number of motions required to perform nearly any operation, yet, more often than not, the employment of improved methods of doing the work and the introduction of mechanical aids, will result not only in greater saving of both time and money, but will accomplish the work with far greater efficiency than could ever have been obtained through its performance by human hands, no matter how scientifically the motions to be made by them might have been planned.

In addition it has been found that such improved devices tend to release from racking toil human beings

(Continued on page 72.)

Staple Machinery

THE old idea about machinery was that every piece was a special product, made to fit the place where it was to go, and generally unfit to go anywhere else. This was true, not only of tools and other operative machines, but also of such simpler things as shafting, hangers, couplings, pulleys, etc. Shafting was turned out of round iron to sizes which would clean up all right, and the pulleys which were to go on that particular length were bored to fit. If a new pulley was wanted later, the shop foreman calipered the place where it was to go and filed a piece of wire to fit the calipers, and sent this along with the order, so that the new pulley might be bored to correspond to its particular location. The idea of being able to transpose anything about the shop was not considered, and, in general, the equipment was as local as the building in which it was installed, and usually such a transmission was tinkered along so that it lasted until the whole establishment was reconstructed at some later date. Those were the days of the millwright and his gang, of the men who came into a place and constructed the power transmission equipment on the spot, and who made things to fit the places which they found and got the power to points where it was needed at the moment.

The millwright is needed occasionally to-day, and when he is wanted it is sometimes very difficult to find him, because his trade has become almost obsolete and his occupation nearly gone. The need for his work has largely been supplanted by the fact that almost all that he used to build on the spot, in the old days, is now, in these modern times, manufactured in quantity, according to standardized designs and proportions, rendering it possible to lay out a transmission system beforehand and purchase all the parts out of stock.

This means that such things as shafting, pulleys, and all the rest of a transmission equipment have become almost staple articles of commerce, made to gauge dimensions, designed for maximum efficiency, both in operation and handling, and capable of purchase from manufacturers or dealers without the delays accompanying specification and special ordering.

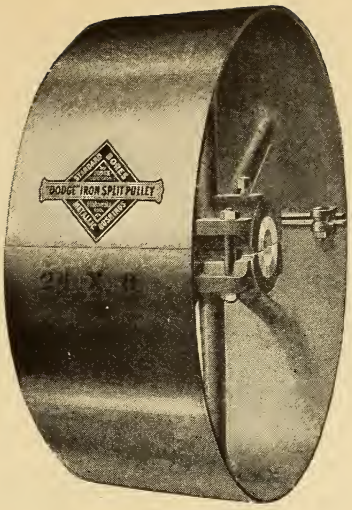
It is true, of course, that even with standardized articles there are various grades and values of articles intended for similar service, just as in the case of the older staples, and it is necessary for the critical user to employ his judgment in the selection of his equipment, taking into account the proper relation of the machinery to the work and the probable life of the job.

In some cases it is essential to inspect and examine carefully every piece which is offered, particularly when there are differences in design and manufacture. In other instances it is safe to select from the stock of manufacturers who have themselves become standard makers and even standard bearers, since this simply means the acceptance of the specialized work of engineers who have worked over the subject and put into their product the results of experience and ability. In this respect the purchase of staple machine parts does not differ greatly from that of other kinds of merchandise, and the dependence which is placed upon a manufacturer's reputation is about the same in both cases.

It must not be assumed that absolute standardization is desirable, even in such material as transmission machinery, since any hard-and-fast rules act here, as in other cases, to hold the art in rigid shackles and impede its development and improvement. The true principles of standardization include such carefully selected points as are essential to obtain the advantages of interchangeability, of repetition in manufacture, and of efficiency in erection and operation, while leaving open the way for continual development and progress.

DODGE

Split
Iron
Pulley



DODGE

Split
Iron
Pulley

"The Best on the Market"

The J. I. Case Threshing Machine Company, Racine, Wis., operates one of the largest plants of its kind in the world. In fitting out a new department recently, they investigated the merits of different makes of metal pulleys, and after careful consideration of all the information collected, they decided in favor of the *Dodge Standard split iron pulley* as "the best on the market." The initial order was for fifty-nine pulleys with the Racine branch of the Badger Machinery Company, Dodge selling agents at Racine and Milwaukee. The sizes range from ten inches to forty-eight inches, and delivery was made in two days after receipt of order.

When a power user buys a piece of machinery with the name Dodge stamped on it, he gets more than prompt delivery. He is buying the ability, the accuracy and the experience of thirty years of successful manufacturing.

The Dodge Standard split iron pulley illustrates the Dodge Idea of standardization. Being split it can be taken down and mounted with only a few moments work and without disturbing other equipment. Because of its interchangeable bushings it can be moved from one place to another—to shafting of different sizes.

Dodge metal pulleys are made to secure the maximum of strength and rigidity. The rim is cast whole, split by fracture, and when drawn together is practically solid. There isn't a riveted joint in the pulley—it can't bend out of shape, and is fastened to the shafting by compression, re-inforced by two set screws. It will always run straight and true.

We maintain branches in ten principal cities of the United States, and in every locality of any consequence there is a stock carrying agent. The next time you are in need of metal pulleys, try the Dodge Standard iron split. If your requirements must be filled on the moment call us on the phone *collect*. We are sure that the efficiency and economy of our goods, as well as the service, will please you.

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Lifting Loads

WHEN an efficiency engineer undertakes to raise the standard of performance in a manufacturing establishment he generally finds that he has to distinguish between the things which ought to be better done and those things which ought not to be done at all, at least in the way in which he usually meets them. Time studies of machining operations enable the most efficient rates for the different kinds of work to be determined and permits the introduction of methods intended to bring the efficiency of the entire force up to a close approximation to the determined maximum, with beneficial results to both workman and employer. Changes in the arrangement of work, in the sequence of operations, and in the general planning of the manufacturing end of the business—all these enter into the things in which improvement may be sought. There is one thing, however, in which no effort at improvement should be attempted, and that is in the use of human muscle to lift heavy loads. A man is provided with strength to do things which need immediate attention, directed by individual skill, under proper training and the exercise of brains; but to use this physical strength simply to overcome the force of gravity, as a regular occupation, is one of the things which the efficiency engineer should endeavour to abolish.

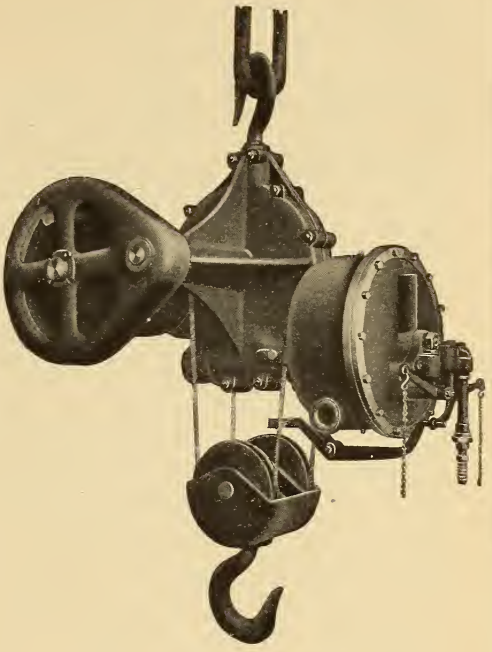
It is interesting to note that a continually improving department of engineering work lies in the production of mechanical appliances to this very end. An examination of almost any modern machine shop or foundry will reveal a marked diminution in the number of men whose work is simply to lift and move things about. The labouring gang, formerly very much in evidence, has been replaced by the traveling crane, by the industrial railway, and especially by the overhead tramrail, carrying some type of power hoist.

When the tramrail was first introduced it was employed, as its name indicates, to provide principally a means of enabling a load to be carried about, the lifting being effected by some form of hand hoist. The ease with which power could be applied to such lifting machinery, however, has widely extended its scope, so that in any shop in which compressed air, for example—and there are few modern shops in which this valuable auxiliary is not now used—an air hoist may be used to such advantage as to render manual labour almost wholly unnecessary for lifting purposes. It is in such methods that some of the most effective developments of efficiency will be found; and when efficiency is understood in its most intelligible definition, that of the reduction of wastes, and applied especially to the reduction of the waste of human energy, the highest returns may be expected. This means that the wasteful human energy should be replaced, so far as possible, by more efficient means.

It has been said that one of the chief characteristics of the coming epoch is that resulting from the manufacture of power, but to this must be included the effective transmission of power to points where it can be used in machines of maximum effectiveness. For this element in the work there is always an opportunity for the use of compressed air, and it is this which drills holes, fills them with rivets, brings the material to the points where it is to be worked, erected and secured; so that the present availability of power in the stored form of compressed air renders some of the most efficient tools of modern work possible.

By the use of such available power the work, not only of lifting loads, but of using the load which is lifted at the point desired at the moment it is wanted, enables the inefficiency of man's muscle to be replaced by the high efficiency of his judgment, and the result is appearing both in the mechanic and in the results of his work.

It is Better to Use an "IMPERIAL" Air Motor Hoist



"Moving time" is all the time, in shop and foundry. Tools, castings, patterns, molds, stock, work—they all have to be lifted and moved, every hour of the day.

You **can** do all this by man-power. **But it is cheaper, better, quicker, to do it with an "Imperial" Air Motor Hoist,** which is many man-power and far more steady and reliable than any manual means of hoisting.

An "Imperial" needs no attention, for it is enclosed, self-oiling, self-locking, self-stopping at end of lift.

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COMPRESSORS ROCK DRILLS ELECTRIC-AIR DRILLS
CORE DRILLS PUMPS PLUG DRILLS PNEUMATIC TOOLS

Clean Hardening

IN nearly every industrial operation there is a conflict between opposing conditions, and the final result is generally a compromise, in which the favourable elements are made as strong as practicable and the unfavourable ones are minimized.

Thus, in the operation of infusing soft steel or wrought iron with carbon, for the purpose of increasing hardness and rendering the material suitable for subsequent heat treatment, the old-time practice was to use some form of animal charcoal produced from calcined bone, burnt leather, or similar material, and to attempt to introduce the necessary amount of carbon by this means.

It is undoubtedly possible to effect some case-hardening action by the employment of animal charcoal as a carbon infusing substance; but, unfortunately for this process, carbon is not the only element present in bone or leather charcoal. The difficult and peculiar element phosphorus is also very much in evidence, and experience has shown that there is almost no substance for which iron or steel has a stronger affinity than phosphorus.

The two objectionable properties of iron or steel are those known as "red-shortness," or brittleness when heated, due to the presence of sulphur, and "cold-shortness," or brittleness and weakness when cold, due to the presence of phosphorus.

Red-shortness can generally be avoided by the elimination of sulphur from the fuel, and it is for this reason that coke or charcoal is used in the blast furnace and gaseous fuel in the steel furnace.

With sulphur out of the way, there remains only the phosphorus to be dealt with. In the Bessemer process of steel making the method is to use ores and irons which are so low in phosphorus as to remove all probability of injurious proportions of the objectionable element. With the open-hearth process the use of a basic lining to the furnace, which has a stronger affinity for the phosphorus than is offered by the metal, enables a product practically free from phosphorus to be made from a metal which in itself is fairly high in the objectionable element.

When all this care is taken to keep the phosphorus out of the original material, it seems remarkable that manufacturers should use a hardening substance which, itself, is capable of re-introducing the undesirable material again into the finished product.

A soft steel, pure and free from any objectionable substances, is the ideal material for machinery operations. When, after being formed into shape, it is attempted to harden such a steel, it seems a very short-sighted proceeding to introduce into this ideal material the very substance which, all along, it has been the especial effort of the metallurgist to ward off and keep out of the way.

The employment of bone charcoal and similar substances for case hardening represents the wrong way to do it, while the use of pure hardening substances, manufactured in the chemical laboratory and containing only carbon and valuable steel alloy elements, forms the modern scientific method of converting soft finished steel products into the hardened parts demanded by modern mechanical engineering.

The importance of using proper substances for infusing hardness into steel will be realized when the extending use of such processes in modern shop practice is considered. Engineers are turning from the efforts to produce improved tool steels, to which so much attention has been given of late, and beginning to direct their attention to the possibilities offered by the selection of soft and easily worked steels, of moderate first cost and maximum machinery efficiency, and the value of processes of subsequent hardening, now so effectively developed. This is undoubtedly work in the right direction, and it should not be impeded by the use of unsuitable materials.

Why use bone for casehardening
See what it contains??

LABORATORY OF C. L. CONSTANT
42 NEW STREET
NEW YORK CITY

CERTIFICATE OF ASSAY

No. 42704 New York, March 23, 1912.

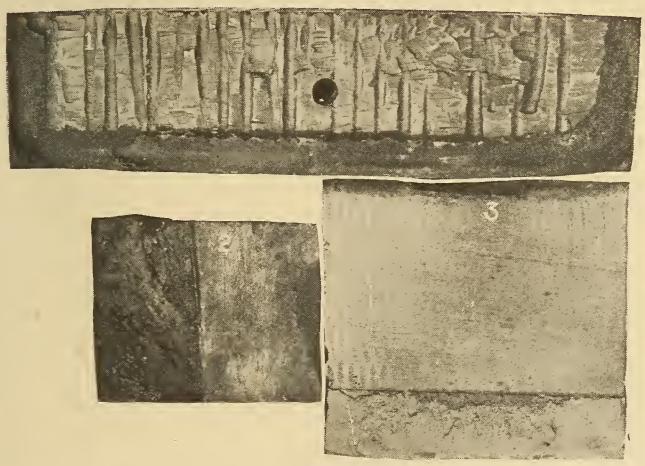
THE SAMPLE OF "**Case Hardening Bone**"
FROM Bought by us in open market for you
contains

Phosphoric Acid 27.16%
Equivalent to
Phosphorus 14.20%

TO **The American Infusion Steel Process Co.**
Yours truly,
Signed by C. L. CONSTANT.

"STELPRO"

Contains no bone, therefore no Phosphorus



Sectional View Showing Depth of "Stelpro" Infusion

L. C. S. + "S"

Low Carbon Steel
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Equals
Better than
Tool Steel Results

"STELPRO"

A Scientific
Hardening Mixture

A Suitable Material

For Hardening, Wearing and Cutting Surfaces

Class "A" for cutting tools, Class "B" for wearing surfaces

Write for Letters from "Stelpro" users, illustrated booklet and full information

American Infusion Steel Process Co.
60 Broadway, New York

OUR PROPOSITION AND YOUR OPPORTUNITY

The Beautiful Rio Grande River

Land as Rich as the Valley of the Nile

YOU can burn less fuel, swallow less medicine, wear less heavy clothing and save money easier in Texas than elsewhere in the world. You can plant something and harvest something three hundred and sixty-five days in the year. You can raise practically everything raised in every State in our country, and in every country on earth. You can raise three and four crops of vegetables in succession—on the same ground—in the same year.

Our Booklet, Sent Free, Tells The Story

Insure Your Future Against Want

MOST men have a longing to become millionaires. It seems to be a popular idea that happiness and contentment can be associated only with unlimited wealth. There is no doubt we should be considered benefactors of our race if we could tell our fellow mortals how to become wealthy. We make no such claim and have no such power.

The man or woman who would possess a fair supply of this world's goods, must first learn to spend less than they earn, then learn how to put their saved dollars to work for them. No man ever got rich by the 3% route. It is also well understood that no one gets rich by hoarding money.

A few men have gone to bed poor at night and were rich when they got up in the morning. These cases, however, are few and far between. There is no quick and easy way of getting rich.

Courage and energy count. The more intelligence a man has, the greater his earning capacity. The laborer plowing a field works harder and longer than does the ranch superintendent, who receives ten times, or possibly one hundred times more salary.

The Rio Grande Valley

the land of realization for the man of limited capital

The Land of Promise

that fulfills its promises

Nine Weeks' Growth of Corn

12,000 Acres in a Three Crop Country

THIS Company owns over 12,000 acres of land in Hidalgo County, known as La Jara Farms, in the Rio Grande Valley of Texas. The project has so many remarkable features that it is impossible to cover them all.

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334 FIFTH AVENUE

New York

Our Proposition and Your Opportunity

WE will deliver to you a forty-acre farm within easy distance of railroad, churches, schools and business houses—all good, productive, level land—providing you pay 10% down and a few dollars a month.

When payments are completed you receive a deed to the forty acres, which should produce an income of from $2,000 to $20,000 a year. $20,000 is equal to 5% interest on $400,000. Prices are subject to advance without notice.

If you cannot go to Texas to select your own farm we will allot you a plot best suited to your wishes. You may have three months in which to personally inspect your farm, or make investigation. If, for any reason, you are dissatisfied we will exchange your farm for any other unsold tract.

Any time you choose to complete your payments a discount will be allowed from the amount still due. You are not spending money when you invest it in fertile land like this—you are merely changing the location of your funds—and in its new location it should yield larger returns.

A Profitable Field of Cotton

Crop Failures Are Unknown in the

Rio Grande Valley, Texas

A Valley Located
Where frost is not to be feared
Where three or four crops a year
may be raised on the same land

A Land of Opportunity

for even the inexperienced

The Rio Grande Valley Company
334 FIFTH AVENUE
New York

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IT is a plain circular, a plain statement of facts told in a plain way, telling a true story, which will appeal directly to you and will show you how a few dollars securely invested in a Rio Grande Valley Farm will net an assured income of from $2,000 to $20,000 each year.

The circular contains much valuable information concerning

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Industrial Press Co.

KANSAS CITY, MO.

Power Factor Meters

(Concluded from page 53.)

of powerfactor meter no connection is required between the fixed and the moving elements, nor is any control spring necessary, as the controlling force is electromagnetic. The moving element is, therefore, very light, and the friction and bearing jewel wear a minimum.

All the Westinghouse switchboard types and the polyphase, portable types are arranged to read lagging or leading powerfactor on the upper half of the scale, and for reversing power on the lower half. The switchboard types are adjusted for one standard frequency; the polyphase portable are adjusted to any frequency between 25 and 60 cycles. The single phase portables indicate for *o cycles on one half the scale, and for 25 cycles on the other half. The portable meters are very convenient for investigating the powerfactor of motor loads and assist very materially in improving the operation of the system.

Hydro-Electric Practice

"Hydro-Electric Practice," by Henry A. E. C. Von Schon, octavo, 410 pages, 239 illustrations, second edition, with much important matter added. J. B. Lippincott Co., Philadelphia, Pa. Price, $6 net.

Owing to the phenomenal success of the first edition of Von Schon's "Hydro-Electric Practice," which has so well met the exacting demands of the engineer, the manufacturer, the investor, the financier and the promoter, its publishers, J. B. Lippincott Co., have been compelled in ten months from publication to announce the second edition of this most excellent book. The second edition has had incorporated many important additions and changes and should be read by all interested in hydro-electric development.

Foreign Salt Market and Industry

Common salt, one of the cheapest and most widely distributed necessities of the face of the earth, is controlled in most important and civilized countries by monopolies, according to a monograph, "Foreign Salt Market and Industry," just issued by the Bureau of Manufactures of the Department of Commerce and Labor. Monopoly of the product is made possible by the fact that in nearly every country the raw salt must be refined before it is fit to use, and the refining process often involves considerable expense.

In England a concern known as the Salt Union, Ltd., controls about 90 per cent. of the total amount consumed. In France a combination of twenty-two mines produces over one-half the sale consumed in the country, and their output is practically all handled by one selling organization, while another handles most of the marine salt. These organizations determine prices to retailers. The cartel system, or the voluntary combination of independent dealers, is the feature of the German trade, specific rules governing output and prices being laid down. In Mexico a single company handles a large proportion of the refined salt sold; and in Canada, though there is no monopoly, one or two large companies greatly overshadow the rest. The Government exercises a monopoly or a partial monopoly of the salt trade in Ecuador, Peru, Venezuela, Italy, Roumania, Austria-Hungary, Switzerland, Servia, Turkey, Greece, China, Cochin China and Japan.

American refined salt is being sold in increasing quantities abroad. Its chief competitor is one brand of English salt, which has penetrated to every corner of the world.

In Chile the deposits of sale are almost limitless. One bed covers about 200 square miles, with an estimated depth of more than 300 feet of rock salt, much of which is 99 per cent. pure. This deposit is estimated to contain 3,000,000,000 tons and covers but a small portion of the salt deposits in the northern part of the country.

(Concluded on page 72.)

The
Constructor

A Handbook of
Machine Design

By F. REULEAUX

Authorized Translation from the Latest German Edition
BY
HENRY HARRISON SUPLEE

SINCE the first presentation in the English language of this monumental work, it has found its way into a large proportion of the engineering offices and machine works of the United States and Great Britain, and to-day it is recognized everywhere as the **Standard Treatise on Machine Design.**

Its influence upon the design and proportions of machines of all kinds has become as powerful in America as it had already been in Europe, so effective has been the presentation of correct theory and sound practice in its pages.

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Investing Your Money

THE professional man and the business man have the necessary educational equipment and the practical experience to understand the conditions governing the judicious investment of money.

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FINANCIAL DIGEST

Information on industrial and other securities of value to investors and men of affairs.

OF THE

INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

IT is a fact that with the possible exception of politics there is no good reason why business should not continue to improve. The crop reports are splendid and the weather favorable; consequently, our harvest bids fair to be one of uncommon plenty. We get encouraging news from all sections of the West, and likewise the South. Small merchants throughout the country, especially in farming communities, send in favorable reports, while the great stores in larger centers are doing a satisfactory business, and most of them are under, rather than over, stocked, which fact furnishes a reasonable basis for expecting increased buying in mercantile lines.

The steel plants report a highly prosperous condition and manufacturing lines generally are in good shape; thus it will be seen that there is every reason to anticipate an early return of normal prosperity, and little or no excuse for the fear and unnatural conservatism that are being manifested, especially in matters pertaining to finance.

In our judgment, the inactive situation in the financial world is due largely to the fact that important business interests persist in throwing their influence behind men and methods no longer trusted by the public.

In the light of recent disclosures as to improper, if not criminal connection between politicians in high office and corporations seeking special privileges, is it any wonder that the layman hesitates to take seriously promises and prophecies that emanate from such quarters? Is it any wonder that people lend a willing ear to those who advocate reform in our present methods and greater individual rights in securing justice through the ballot box? Is it any wonder that we have begun to accept as true the accusation that our rich men of affairs are willing to prostitute our representative form of government to the achievement of private gain? The answer is no, and the wonder is that intelligent American voters have so long remained indifferent to what is now a confessed fact, that men influential in the affairs of the Government have lent themselves as willing tools in extending the power of a commercial system that is as rotten and debased in its character as the political system which permits it to feed and grow fat at the expense of the people.

There certainly can be no doubt in the minds of those who are in touch with public sentiment that in order to restore confidence in the financial methods of this country, it is going to be necessary for men who are prominently identified with banks and banking houses and large corporations to

take a very firm stand in favor of a higher moral policy in business, and prove their sincerity by dissolving partnership with discredited political bosses, regardless of their party affiliations, and aiding the Government by forming a more legitimate and practical method of insuring honest procedure in all lines of trade.

Question—What do you think of curb stocks?

Answer—As a rule stocks sold on the curb are highly speculative. They are usually low-priced and if purchased at all most of them should be purchased as speculations and not as investments. There are, of course, a few exceptions to this rule.

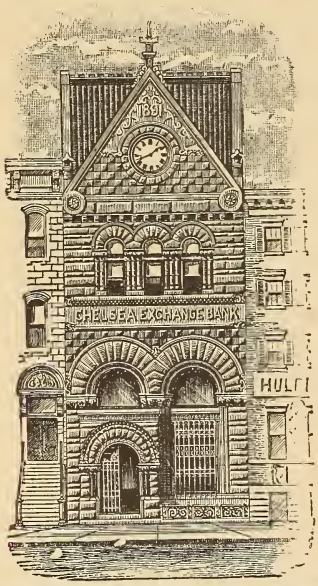
The United States Rubber Company has given out some fascinating figures as to the income-producing possibilities of its huge Sumatra plantation. With the large amount of capital that the company can put behind this enterprise and its ability to await the development of the trees, it will no doubt produce tremendous future profits to the shareholders of the company.

Foreign Competition for Large Pipe Contract

J. G. White & Co., Incorporated, of New York and San Francisco, have purchased 124 miles of 12-inch steel pipe, to be used by them in building a natural gas line for the Midway Gas Company in California. The pipe will weigh approximately 11,000 tons, and, with transportation, will cost approximately $600,000.

Quotations were asked from British, German and French manufacturers, and the best foreign price was that of a British firm, which, exclusive of duty and freight, was approximately double that at which

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

The Chelsea Exchange Bank

Located at

Thirty-fourth St. and Eighth Ave.

NEW YORK

Safe Deposit Vaults. Boxes $5.00 per year up

A Continually Growing Bank in a Continually Growing District

the contract was placed with the National Tube Company, a subsidiary of the United States Steel Corporation.

This indicates the remarkable resources of the United States for cheap production of steel and the advantages of buying this kind of manufactured material in the American market.

The present congestion of the steel trade, with many orders booked half year ahead, would indicate that the criticisms on the rapid expansion of American steel mills were entirely without foundation.

It is interesting to note that we are now making one-half of the world's iron. Since 1860 our per capita consumption of iron has jumped from 60 pounds annually to 680 pounds. We are now producing 30,000,000 tons of iron and have a capacity of 32,000,000 tons.

Leads World in Asbestos Manufacturers

In 1911 the United States excelled the other countries of the world in the conversion of raw asbestos into manufactured products, but a very small percentage—less than 1 per cent. of the asbestos used—was mined in this country, by far the larger part being imported from Canada. The total production in the United States for 1911, according to the United States Geological Survey, was valued at $119,935; the raw material imported from Canada was valued at more than eleven times that amount. Canada's production of asbestos in 1911 was worth nearly $3,000,000.

In the wholesale shoe trade there has been an advance of from 10 to 20 per cent. all over the country. This is the natural result of the advance in the price of leather, and apparently the top has not yet been reached.

Don't Call It Luck

Investigation
Before—not After
Investment

that is the real reason for success in Real Estate Investments

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Unequalled

Editorial Strength
Conceded

Covers the Markets of the World

Published Daily
Morning and Afternoon

Subscription Price
Three Dollars a Year

40 Stone Street New York

Question—What do you think of the common stock of the International Nickel Company?

Answer—This stock has recently been showing considerable strength, which is traceable to a rumor that the dividend will soon be increased. The company will show increased earnings this year and the stock is very favorably regarded.

The Kerr Turbine Company, Wellsville, N. Y., advises that over 700 of their machines, aggregating more than 50,000 horse-power, are in active service, and that more unfilled orders are now booked than at any previous time in the history of the company. Although their plant has been materially enlarged, a night shift has been necessary for the past two and a half years.

Among recent orders are the following: One 350-kilowatt turbo-alternator for the Brooklyn refinery of the Standard Oil Company; two 2,800-gallon-per-minute turbo-pump units for Tidewater Oil Company; two 75-kilowatt and one 35-kilowatt lighting sets to American Shipbuilding Company for the new steamer *City of Detroit;* two 75-kilowatt lighting sets for waterworks service, city of Chicago; one 60 brake-horse-power turbo-generator with Pony brake attachment for the University of Melbourne, Australia (this unit takes steam at 200-pound gauge, with 200 degrees superheat, and exhausts to 28 inches vacuum); one 215 horse-power turbo-blower for Peoples Gas Light & Coke Company, Chicago (the tenth set of this size ordered by these people); two underwriter fire pumps driven by 200 horse-power Kerr turbines for Stieger & Sons piano factory, Stieger, Ill.; one fire pump driven by 265 horse-power Kerr turbine for B. M. Osbun Company, Chicago. This last-named will be the only turbine-driven fire pump in the city of Chicago.

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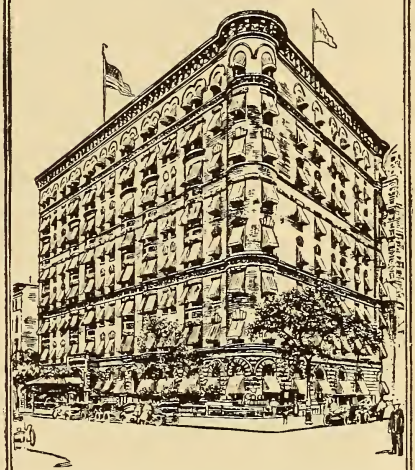
New York City

OFFERS SUPERIOR ACCOMMODATIONS AT MODERATE RATES



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Conducted on European Plan

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All modern conveniences, absolutely fireproof, a few minutes' ride to Theatres and Shopping District by elevated road, surface lines and Fifth Ave. stage. Subway express and local station at door. S. L. ROOT, MANAGER

Attractive Summer Rates

New Chicago Office of The Jeffrey Manufacturing Company

The Jeffrey Manufacturing Co., of Columbus, Ohio, announce the removal of their Chicago branch office to the seventeenth floor of the new and modern McCormick building on Michigan avenue. This company has branch offices in New York, Boston, Pittsburgh, Chicago, St. Louis, Denver, Atlanta, Charleston, W. Va., Birmingham and Seattle, as well as Canadian office and works at Montreal.

TO INVESTORS! WE HAVE VALUABLE SECURITIES FOR SALE. Gilt edge real estate bonds, bearing interest at 6 per cent. Payable semi-annually. First and second trust notes. BLANKENSHIP LAW & COMMERCIAL CO., Inc., Suites 525, 6 and 7 Colorado Building, Washington, D. C.

"The
Santo
Vacuum Cleaner

collects the Dust right here in the dust bag, and doesn't scatter it about. See, the bag is nearly full of that fine Powder Dust. That's the Dangerous kind."

Let us tell you more about the Santo. It's worth your while.

KELLER MANUFACTURING CO.
DEPT. "C." PHILADELPHIA, PA.

The backers of the United States Motor Company are endeavoring to work out a reorganization scheme for the company, with a view of raising additional working capital. The company has been in a bad way for some time past and it is believed that with additional working capital and some changes in its management, it can be developed into a profitable enterprise.

Question—Would you advise one to withdraw money from a savings bank to invest in preferred stocks or bonds?

Answer—This depends largely upon the character of the stocks and bonds under consideration. One of moderate means should never withdraw all of their savings from a bank. It is well to have some cash in the event of emergency, and neither should one keep all of their savings on deposit at 3½ or 4 per cent., because there are many good preferred stocks and bonds paying as high as 6 per cent.

An Omission

In the article by James Steelman, in the August issue of CASSIER'S MAGAZINE, upon the subject of welding as a caulking process, it was omitted to state that the oxy-acetylene process, so effectively used in securing the tightness of the Boulder pipe line, was that of the Davis-Bournonville Company, of New York, who are well known as makers of apparatus of the most efficient character for all industrial operations in which the intense heat of the oxy-acetylene flame is employed. The office of the Davis-Bournonville Company is at 90 West street, New York.

Foreign Salt Markets and Industry

(Concluded from page 65.)

Russia also has immense deposits of salt, which so far have been but little worked; and other large beds are found in Prussia, England, Ireland, South Africa, India, Austria, Spain and Canada. In the United States salt is mined like coal in Louisiana, Michigan, Kansas and other States.

An Illustration of Modern Efficiency

(Continued from page 53.)

whose effort can be employed to better advantage both to themselves and mankind at large.

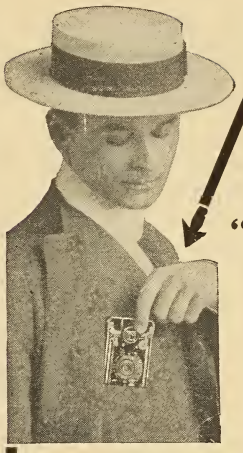
In the early days of railroad building the dirt or other material was unloaded from the cars by men with shovels, and an important improvement was the method of unloading trains by plowing off their contents. This was a great step forward, but as the plow had to be hauled through the train by locomotives, requiring sometimes as many as three to do the work, and the train had to be held stationary while the unloading was done, the system had few advantages, but when the Lidgerwoods put a pulling engine on the train, taking its steam from the locomotive, the whole system became flexible and the operation so quick and cheap that it was immediately adopted.

So important and staple has this unloader become for railroad building that among railroad men it is refered to merely as a "Lidgerwood," and yet it is an interesting fact that while the whole system, including the cars, trains, plow, etc., are thus called "Lidgerwood," it is only the powerful hauling engine which operates the plow that is made by the Lidgerwood Mfg. Co.

It will be seen, therefore, that while the system of plowing the load off of trains was a great step forward from former methods, it was not until the introduction of the Lidgerwood Rapid Unloader that the system became really efficient, due to the great reduction in unnecessary motions and expense and greatly increased flexibility.

In fact, so efficient has this unloader proved that at present more than a hundred railroads own and use it, and in some cases more than twenty unloaders are in use by a single road.

This unloader played a most important part in the digging of the Culebra Cut at the Panama Canal, where thirty of them were in use for handling of the 100,000,000 cubic yards of rock and earth excavated



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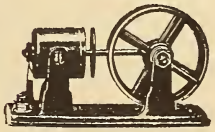

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there. The principal work of unloading the spoils was done by eleven of these unloaders placed at the main dumps, and official figures show that they unloaded an average of about 60,000 cars a month with loads of 1,250,000 cubic yards.

There has just been issued by the Lidgerwood Mfg. Co. a most attractive and instructive book descriptive of their rapid unloader, which contains a series of fine half-tone cuts, each illustrating a different use or application of the unloader system and including many views of its operation on the Panama work, as well as views of the unloader disposing of rock from the Grand Central terminal improvements at New York, and others showing them building railroads in the North and Northwest, among them being one showing the unloader plowing off the rock and dirt at the Tabernilla Dumps, Panama Canal, and working without difficulty on a badly settled track and on a 14 per cent. grade.

Another view shows the flexibility of the unloader where, on the Nashville, Chattanooga & St. Louis Railway, near Paris, Tenn., it is shown filling from trestle 1,300 feet long engaged on a fill to contain 210,000 cubic yards of earth. In this case the plow is moved in one direction, the train in a counter one, thus dropping the entire load within a space of 50 feet.

To those interested in transporting and unloading earth, rock, ballast, ore and similar materials in large quantities this book will prove of great interest, as this system has been found by engineers and contractors to be the cheapest method known for the performance of such work, and the actual cost of unloading by this method has been found almost too small to calculate, while the greatest economy of the system is found to be the low cost of equipment, trackage and transportation.

A copy of the book may be obtained by addressing the Lidgerwood Mfg. Co., 96 Liberty street, New York, and mentioning CASSIER'S MAGAZINE.

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THE LATEST CATALOGUES

Power Pumps

Catalogue No. 90, entitled "Power Pumps," has been issued by the Dean Brothers Steam Pump Works, Indianapolis, Ind.

The book, which contains many illustrations, describes some of the various types of pumps manufactured by them. All the pumps shown in this catalogue may be driven by belt, electric motor or other power, and especial attention is called to the fact that their duplex power pumps are driven by gears at each end of the crank shaft, and as no power is transmitted from one crank to the other, tortion strains between the cranks are eliminated.

Those having to do with pumping matters will be interested in this book and should send for a copy, which will be sent them on request.

Machinery for Steel Works, Blast Furnaces and Power Plants

The Mesta Machine Company, whose machinery for steel works, blast furnaces and power plants can be seen in most of the large iron and steel works, and in many of the power plants of the United States, have recently issued a handsome booklet showing some illustrations of their plant and its products.

This company manufactures gas and steam engines, barometric condensers, air compressors, steam hydraulic quick-acting forging and bending presses, rolling mill machinery, iron and steel rolls and pinions, machine-molded and cut gears made of iron and steel, and a perusal of the booklet shows some very interesting machinery, either on account of its immense size or because of novelty in design.

The only limit as to size and weight of machinery built by this firm is that which the railroads can handle, and castings weighing over 100 tons have been made in their foundries and finished in their shops.

The views of the steam hydraulic quick-acting forging and bending presses which they manufacture for the United States and Canada under a contract with Haniel & Lueg of Dusseldorf, Germany, and the text briefly describing them is of much interest.

The Mesta Machine Company will gladly send a copy of this booklet to anyone interested who mentions CASSIER'S MAGAZINE.

Leyner Drill Sharpeners

"Golden Opinions by the Other Fellow" is the title of a book received from the Ingersoll-Rand Company, of 11 Broadway, New York.

It contains a number of facsimile letters from users of Leyner Drill Sharpeners, among them one written in Japanese by the engineer of Takata & Co., expressing their great satisfaction with the two drill sharpeners in constant use at the Kosaka Mine, Japan. Among other letters reproduced, all of which speak in the highest terms of the efficiency of the Leyner Drill Sharpeners, are letters from the Cheever Iron Ore Company, Port Henry, N. Y.; the Dixie Meadows Mining Company, Prairie City, Ore.; the contractor for the Cripple Creek Drainage Tunnel, Cripple Creek, Col.; the American Smelters Securities Co., concerning their experience with this sharpener at their El Cobre Mine at Valardena, Durango, Mexico; the United Verde Copper Company, Jerome, Ariz.; Mr. James A. McIlwee, tunnel contractor of Denver, Col.; and the Mine Superintendent of the Old Dominion Copper Mining Co., of Globe, Ariz.

"Golden Opinions" will prove of interest to both engineers and contractors, and a copy can be secured by addressing the Ingersoll-Rand Co., 11 Broadway, and mentioning CASSIER'S MAGAZINE.

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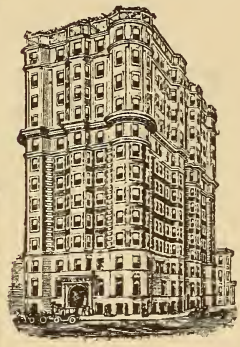

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Derrick Engines

The 1912 edition of the Derrick Catalogue, entitled "Lidgerwood Derricks, Derrick Fittings and Derrick Engines," issued by the Lidgerwood Mfg. Co., 96 Liberty street, New York, has been received. This book will prove of great interest to all who are interested in derrick work.

The Lidgerwood derrick irons are made under the patents of Edward F. Terry, one of the foremost of the practical derrick men of the world. Their main feature is the use of a universal ball and socket connection between the mast step and foot block, which makes it impossible for the mast to bind even if the original setting of the derrick is uneven or the foundation settles unevenly during use.

In this catalogue, which is admirably printed, well bound, and worthy of a place in any technical library, those interested in the details of derrick construction will find by referring to the profuse illustrations that many minor changes have been introduced in the design of the foot blocks, mast steps, mast head irons, goose necks and spider plates, all of which increase the strength and efficiency or tend toward eliminating danger.

One feature of improvement in details is the adoption of uniform diameters for sheave pins for all sheaves in each size of standard derricks, so that sheaves may be shifted as desired from one part of the derrick to another or between derricks and rigging blocks. Standard designs for both guy and stiff leg derricks for operating grab buckets are also shown, together with full lists of irons and rigging data. All the standard styles of steam and electric hoists used for derrick work are illustrated, described and tabulated. The Lidgerwood electric portable warehouse crane is shown, as is also the Lidgerwood-Crawford excavator, wire rope blocks, sheaves, wire rope and wire rope fittings are also catalogued.

Perhaps the most interesting part of the book is contained in the 20

pages of "Installations." These show admirable half-tone illustrations from photos showing Lidgerwood derricks erecting the Woolworth Building, the Municipal building, the Hotel McAlpin, the new Post Office, the Grand Central terminal improvements, and others in New York City.

The Lidgerwood Mfg. Co. will promptly send a copy of this catalogue to those interested in hoisting problems who write requesting one and mention CASSIER'S MAGAZINE.

The Dodge Manufacturing Company, of Mishawaka, Ind., whose power transmission machinery is so largely used, have found it necessary, owing to the increased demand for their products, to open a branch house on the Pacific Coast, and have recently established one at Fourth and Lovejoy streets, Portland, Ore.

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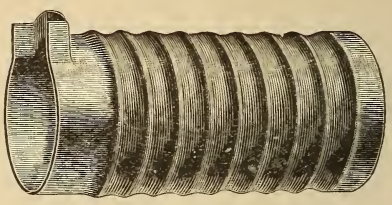

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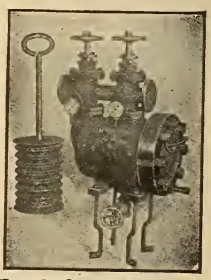

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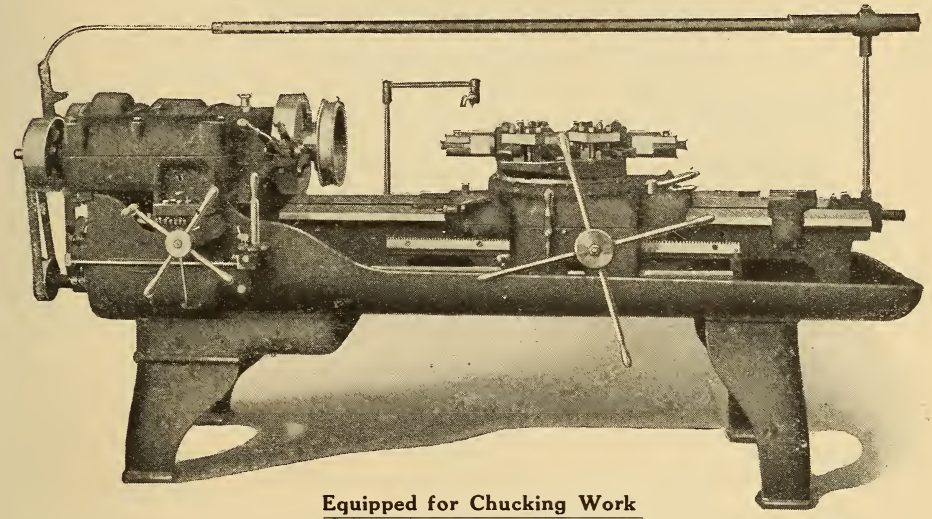

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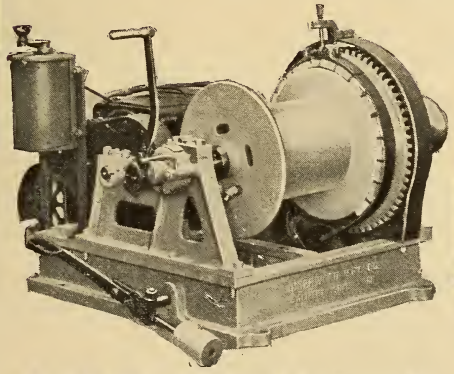

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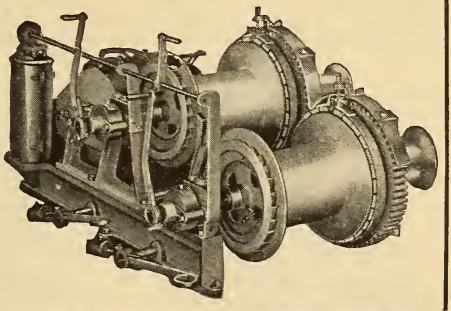

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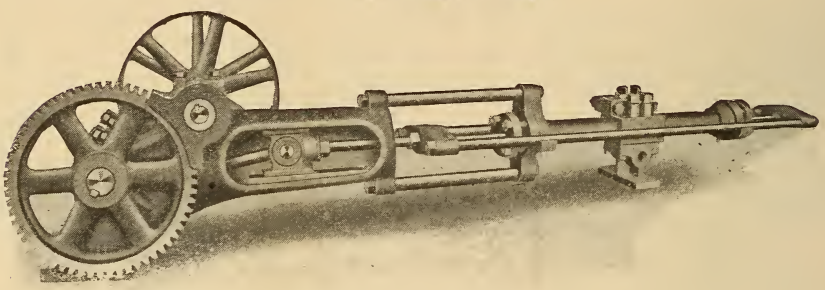

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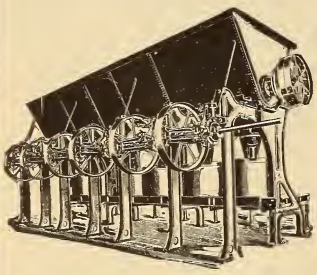

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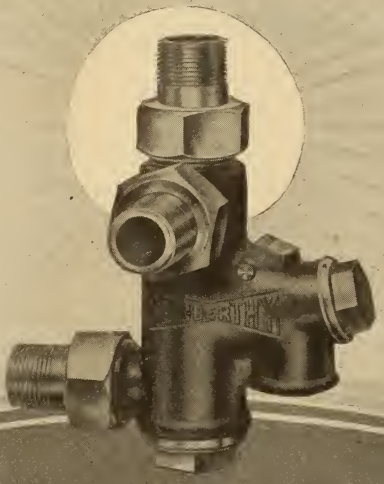

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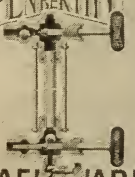

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By Charles S. Lyall

IN the use of high-pressure water supply systems for fighting fire it is most desirable that the pressure at the hose and nozzle shall be regulated automatically and, at the same time, be under the control of the fireman by whom it is being used. This involves the installation of automatic pressure regulating valves at the fire hydrants, a matter which demands especial attention for several reasons. In the first place, the cost of equipping every hydrant with an automatic valve amounts to a large sum, and one which would hardly be warranted in large cities. In the second place, an automatic valve hydrant, if left unused and neglected for a long time, as would be the case in a location in which no fire alarm had occurred for a considerable period, would become unreliable and possibly inoperative. These objections have been fully met by the use of a portable hydrant head, capable of being attached promptly to any hydrant outlet, and containing in itself a number of hose connections, each fitted with an automatic valve. By providing each hose wagon with such portable hydrant heads the connections may be made immediately upon the arrival of the firemen; and since the heads need be no more in number than two or three for each hose wagon, the cost is kept down, while the constant use

(Continued on page 61.)

A Question of Endurance

IT has been found that an excellent indication of the lack of efficiency in a manufacturing plant appears when, under the stimulus of some improved system of production, the transmission of power from prime mover to machinery proves unequal to the task. That this often occurs is the experience of many men who are engaged in endeavouring to improve the efficiency and output of the establishments under their charge when they undertake to introduce improved tool steels, together with heavier cuts and feeds. It is the experience, in many such instances, that the transmission, such as belting, is proportioned too closely to the limit of durable and efficient service, and that any increased demands upon it are apt to be followed by breakdowns, failures, or the indications of rapid wear.

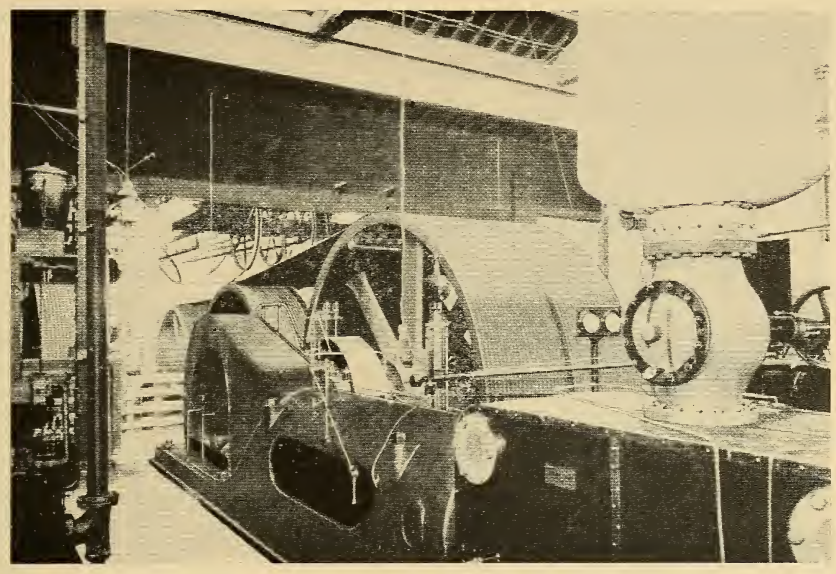
This is a detail of works administration to which sufficient attention has not usually been given, and, indeed, general information concerning the useful life of a transmission under given conditions is not always available. Doubtless the builders of transmission systems have among their records data derived from long experience, and when employed by engineers who are familiar with the conditions under which this information has been obtained such a store of information becomes most valuable. In general, however, it may be assumed that the way to secure a long life for a transmission system, whether of belting or rope, is to provide such a liberal margin of capacity as to cause the initial stresses to be fairly low. This applies not only to the wrapping connector itself, but also to other details of the transmission.

A system, including a belt, strained well up to its elastic limit, in order to make it grip upon pulleys which are of insufficient diameter, carried upon light and flexible shafting, with widely spaced and weakly supported bearings, cannot have the elements of endurance. Such conditions involve excessive friction, high bending stresses, unnecessary wear, short life, and low efficiency. When, in addition to such inadequate provision for ordinary service, there comes upon the transmission some demand for additional power, it is evident that the whole combination must prove unequal to the emergency. If, instead of a sudden call for overload, there is placed upon such an equipment a continuous increase in burden, there is only one thing to be expected—a rapid deterioration, leading to the necessity for a complete replacement of the entire apparatus.

Such being the case when a transmission of inadequate capacity is given a continuous and heavy load, we may expect to find the contrary when a transmission, under steady duty, continues to give satisfaction for a number of years. There is only one way to explain how satisfactory service is supplied; it must be by the use of a proper design, so installed as to provide an ample margin of capacity, keeping the working stresses far within the limits at which breakdown originates.

In designing a transmission, as indeed with any other mechanical apparatus, the question of final cost should be taken into account as well as that of first cost. When the probable duration of the equipment can be estimated, it is practicable to determine the depreciation and interest charges and make a fairly close computation of the final cost upon an original investment. When, however, as is usually the case, there is no positive way of finding out how long an installation is likely to be used, it becomes desirable to take into account all the conditions which can be ascertained and so proportion the overhead charges that the first cost may be sunk at some period well within the probable life, so that any excess of service over that period will be a clear gain, while anything which acts to curtail the life becomes improbable.

DODGE



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Credentials

THE present is the age of mechanical appliances intended to replace the work of men. Formerly the principal reason for using machinery instead of human labour was because of the greater productive capacity of the power-driven apparatus, and this is yet the natural incentive to devise so-called labour-saving machinery. With the developing use of mechanical devices for doing work, however, there has appeared a number of other reasons for their extending use, reasons which, when followed to their legitimate conclusions, cannot fail to have an important influence upon methods of administration and management.

Thus it is well understood that heavy and brutalizing labour, such as lifting heavy burdens, violent exertion under exposure to high heat, as in stoking boilers or operating metallurgical furnaces, drilling and cutting rock in different positions, and similar heavy physical labour, is well replaced by mechanical appliances, even if no other advantage resulted. The men who formerly did such work are far better employed in guiding and directing the power-driven machinery than in straining their muscles beyond reasonable limits.

Again, in the development of repetitive processes the machine relieves the man from the continual and monotonous operations which fatigue the hand and make little or no demand upon the mind, setting the operator free to control and manage a number of tools, upon which he directs his head, using his hands in a reasonable and legitimate manner.

These are but a few examples of the manner in which the engineer is raising the position of the workman from that of a machine himself to that of a director of machinery, and to this industrial development much of the progress of the world to-day is due.

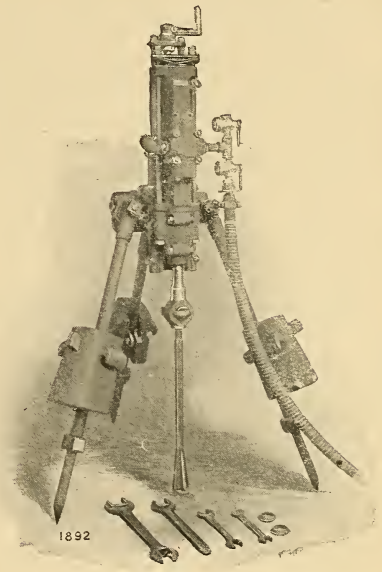
When, however, a machine is so designed as to take the place of a man, or of many men, the inanimate apparatus itself is also placed upon a different plane, and partakes, so to speak, of a portion of the responsibility of the individuals which it replaces. If a man failed to do his work properly, he was held responsible for the consequences, and the rank and position of the skilled workman depended very largely upon his record and reputation. This is still the case, in an increasing degree, of the man; but it has also been largely placed upon the machine, so that apparatus made by builders of high reputation partakes of the standing of the firms by whom it is built. As a natural consequence of this responsibility, the reputation of the manufacturer is dependent upon the performance of the machines bearing his name, and thus both builder and tool have a status to be maintained.

Nearly every man who has built up a reputation for himself and his work has done so by actual performance, by "making good," and when any question arises as to his capacity for any undertaking placed in his hands he is able to produce his credentials and stand upon his record.

The machine which, to such a large extent, is taking the place of the man, must also be able to produce its credentials and show its record; and when this can be done it is placed in much the same position as the skilled workman who has his past work to witness to his ability and capacity. The new machine is in like manner comparable to the new man; it may be most excellent, even better than the equipment which has been in use for years, but it has its record to make and its credentials yet to acquire.

Thus, while methods and devices change, the fundamental principles beneath them reappear in forms which may readily be perceived by the observant engineer and manufacturer, guiding him and aiding him in attaining best results by enabling him to bring to his service both men and apparatus of the highest class.

Investigate the Credentials of the Rock Drill You Buy



When you hire a man for a responsible position, you investigate his record—look up his credentials—and prefer an experienced man if you can get one.

It is good business to buy a rock drill on the same basis. Investigate its record in other places—find out what other users think of it—and decide upon the drill which represents the most practical experience in rock drilling.

If you will investigate Ingersoll-Rand Rock Drills in this way, you will find that they have borne the greater part of the burden in every great rock removal job in the past forty-one years—that they are considered the standard in the world's most profitable mines—that they predominate in the quarries of the country.

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Making Dies from Soft Steel

ONE of the definite elements in modern manufacturing naturally growing out of the general use of repetitive processes appears in the widely extending use of hard dies for forming softer materials into determinate shapes. Various applications of this principle appear, from the drop forging process, using the force of impact, to the mechanical and the hydraulic power press, and in every instance the success of the method is involved in the creation of a demand for a larger number of pieces of the same character, and in the possibility of making dies of some material so much harder than the substance to be worked that the one master die has its reverse form produced in hundreds of thousands of commercial products.

Such a method of working naturally depends almost wholly upon the possibilities of the material of which the dies are made, so that the art of die making has become a most important factor in modern manufacturing. A die, to be satisfactory, must be the precise reverse of the desired finished product. This means that consummate skill is required for its production, and that the highest grade of material must be employed in its construction.

The ideal method of making a die would appear to be by using hardened steel in the first place and working the design directly out in the hard metal; but this is manifestly impracticable, since any material hard enough for use as a die would be too hard to be worked by the tools of the die sinker. The next method—and the one usually employed—is to use a high-carbon tool steel, carefully annealed to make it soft enough for the design to be cut, though with labour and difficulty, and then, by suitable heat treatment, to harden the finished die and render it able to stand the severe duty demanded of it.

Although this latter method is generally followed, it has serious disadvantages. The original material, being of the highest grade of tool steel, is necessarily expensive, besides offering much resistance to the tools of the workman. When the die has been cut, the operation of hardening must follow, and in this critical operation there is abundant room for both warping and cracking, and the work of days may be undone in as many minutes.

It is now well understood, however, that the carbon content necessary to permit a steel to attain the high degree of hardness suitable for die work need not be in the original material, but may be infused to almost any desired extent, even above one per cent. after the machining and die sinking have been entirely completed. This fact has vastly simplified the operation of die making, and will undoubtedly contribute very largely to the increased use of the drop and forging press in repetitive machining. Under such a method, the original material may be an ordinary machinery steel, much less costly than the tool steel formerly used, and, when carefully annealed, very easily worked by the tools of the die sinker. When properly handled, such material is free from distortion or warping under heat treatment, and, apart from the lower first cost of material and the immensely reduced expenses of die-cutting, it may be so effectively hardened as to surpass in service any high-cost tool steel worked by the older methods.

Since the infusion of hardening carbon may be made to almost any desired depth, dies made in this manner may be repeatedly ground and kept in a high condition of efficiency, so that all the conditions for effective operation are fully met.

It has been said that very many processes might be improved if examined in the reverse direction from the sequence of operation ordinarily employed, and that a change in the order of work sometimes enables marked improvements to be secured; evidently the art of making dies comes within the scope of this idea.

How do you make your dies?

Out of high carbon tool steel, annealed to make it soft enough to cut and shape; then after the die is shaped reharden it by suitable heat treatment?

Rather expensive method, is it not? Labor difficult and costly too, and the rehardening operation that must follow often cracks and warps the die, destroying the work of days in a moment, adding more expense and delay.

Dies Come High by This Method, Don't They?

How you should make your dies

out of ordinary machinery steel—much less costly than tool steel—annealed so it can be easily worked by the die sinkers' tools—time saved here—and when die is fully shaped infuse with carbon

with "STELPRO"

Dies made from ordinary Machinery Steel and hardened by

"STELPRO"

cost less, much less, to produce and their hardness will give them service far surpassing dies made by the older and more expensive methods.

BETTER WRITE FOR INFORMATION

American Infusion Steel Process Co.

60 BROADWAY, NEW YORK

Conveying Power

THE question of transport has long been considered a most important one in all departments of industry. In many instances the transport cost forms the largest item in the total price of an article, and the success or failure of an enterprise may hinge upon the transportation facilities obtainable, both for the raw material and the finished product.

There are various kinds of transportation, however, and it would be misleading to limit under the title only such obvious things as the hauling of merchandise over roads by means of cumbrous teams or the swift and smooth conveyance over a railway. Some kinds of merchandise may be without weight or without measurable bulk in the ordinary sense of the term, and yet require transportation in a very material sense before they can become useful or marketable. Such, for example, is the electric current, which, representing an imponderable form of energy, must be transported over a conducting wire before it can be used to produce light or operate a piece of machinery. A similar instance appears in the transmission of mechanical energy, which, originating in a steam engine, hydraulic turbine, or other prime mover, must be conveyed to the machinery engaged in productive work before it has any commercial value.

In many respects this question of conveying power resembles the transport of actual merchandise over a railway. The various elements which make up the details of railway terminal, roadbed, trains, locomotives, station cranes, sidings, etc., have counterparts in the transmission equipment of a manufacturing establishment. In the factory the power generated in the engine room is delivered to the main line-shaft, which must have its roadbed, consisting of bearings, hangers and supports.

Through this the power is carried to points where it is distributed to second, third and succeeding shafts, all requiring their own supporting and directing material, just as branch railroad lines must be equipped; while all along the way are numberless pulleys, the counterparts of the cars carrying their respective loads from various shippers to their customers. As trains have to be made up on the railway, so the transmission line for power has to be assembled, and thus it should be made as easy for pulleys to be added or removed as for cars to be coupled or disconnected. So the commercial problem of conveying power may be considered as a matter of transport, learning many useful lessons from the precedent of the conveyance of merchandise, both as what to do and what to avoid.

The principal difference in the conveyance of power through a transmission system composed of shafting, pulleys, hangers, etc., and the carrying of merchandise over a railway, lies in the fact that the power transmission is continually in one direction and that there is no return track, the load being absorbed and transformed as it goes along. This, however, does not materially alter the general condition of affairs, and does not prevent the two from being generally comparable.

The important thing about a power transmission system lies in the fact that its elements are arranged in "series," so that the efficiency of the whole operation is definitely bound up in the performance of each detail in a most important manner.

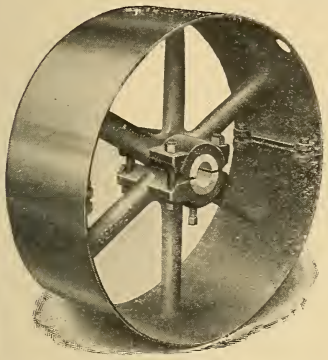
Under such circumstances the introduction of any element of low efficiency acts in a most important manner upon the efficiency of the whole, since the final efficiency of the system is found by multiplying together the efficiencies of all the elements. Even with a fairly high efficiency for every part, this continual product brings the final result low enough, and any low detailed performance drags all the better ones down with it.

OUR TALKING POINTS

Why YOU should install

Jeffrey Power Transmission Machinery

—are gathered from the numberless users.



Every Pulley designed for double belt service.

The Interchangeable Bushing feature of the **New Jeffrey Split Iron Pulley** means a great saving of Time, Labor and Cost.

Every Pulley is available for use on different sizes of shafting.

Being split it can be easily removed or mounted on the shaft without disturbing other equipments, giving it a great advantage over the solid pulley.

The Jeffrey Line includes everything for the mechanical and economical transmission of power for every class of service.

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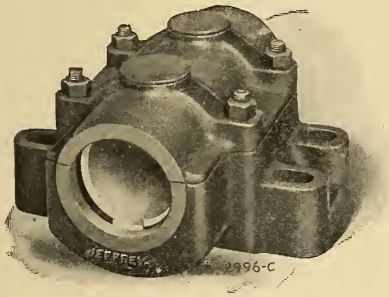

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COAL SAMPLES ANALYZED

VALUABLE DATA CONCERNING WESTERN FUEL, PUBLISHED BY THE UNITED STATES GEOLOGICAL SURVEY

A few years ago a coal analysis was a complicated puzzle to most people. But recently it has become an economic necessity to scrutinize the coal bill as carefully as the food bill, and we have learned that a chemical analysis, when properly made from a sample properly taken, is the surest test of a coal's fuel value. This value is generally stated in terms of the British thermal unit (sometimes abbreviated to "B. t. u."), the quantity of heat necessary to raise the temperature of a pound of water 1 degree Fahr.

Manufacturers and large commercial houses have now found it a matter of economy to determine the heating value of fuel purchased for power or heating, and the coal-testing laboratory is considered quite as important as the accounting room. The United States Government, in making its contracts for coal, requires a guaranty not only as to burning quality, but also as to ash content. It goes even much farther than this and makes analyses of samples taken from each shipment, to determine whether the standard set by the contract is being maintained.

From time to time during the last six years the United States has made analyses of a large number of samples of coal collected by geologists from various States and fields. Most of the samples were taken in anticipation of the publication of a geologic report on the field from which they were obtained, but for various reasons the preparation of the several reports has been greatly delayed, and some of them have been postponed for consolidation with reports on other areas. In view of the fact that the analyses are valuable to persons interested in the fields from which the samples were taken, the Geological Survey has published the data for more than 160 of these samples in Bulletin 471—J.

Iridium a Rare Metal

The smooth writing qualities possessed by gold fountain pens may be attributed to the tiny bit of white metal—iridium—fastened to the tip of the pen. Iridium is an exceedingly rare metal, according to the United States Geological Survey not more than 5,000 ounces being produced each year, of which, perhaps, about 500 ounces are recovered in the United States, mostly from imported platinum sand and from copper ores and bullion. The price demanded for iridium has been increasing rapidly, and in 1911 it ranged from $60 to $64 an ounce for pure metal.

Owing to its unique qualities, iridium finds a fairly extensive use. Most of the metal produced is probably used for hardening platinum. It is further used for various scientific and technical purposes, such as standard weights, pivots, contact points, and, as previously stated, for gold-pen points. Iridium black, an oxide of the metal, is highly valued as a pigment for decorating chinaware.

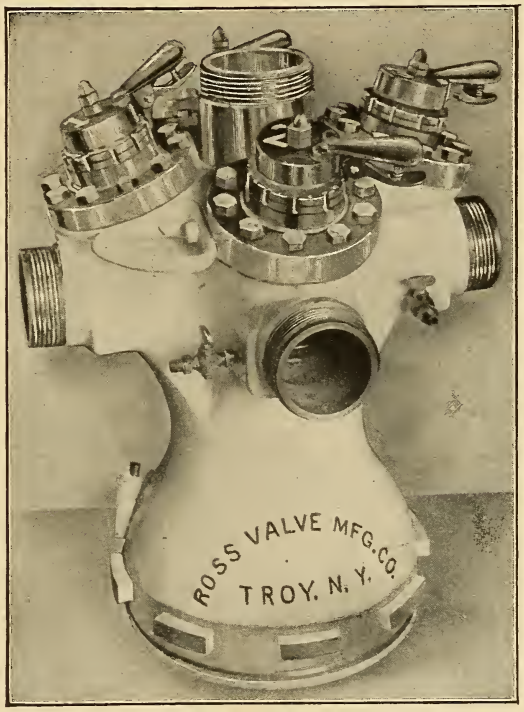
According to the Bureau of Statistics, 3,905 troy ounces of "iridium and iridium in native combination with platinum metals," valued at $210,616, were imported into the United States in 1911.

PORTABLE FIRE HYDRANT HEADS

(Continued from page 51.)

of the valves insures their continual operative condition.

Such portable hydrant heads have been most successfully used in connection with the high-pressure service of the city of Baltimore, and since the equipment of Baltimore, including these hydrants, contains a number of interesting features, some account will be found acceptable.



PORTABLE HYDRANT HEAD

In this high-service fire system each hydrant is set flush with grade of pavements and connected with mains by cutting a hole therein, inserting the end of an 8-inch connecting pipe and welding solidly together, avoiding the use of specials. The hydrant itself is of semi-cast steel, resting on a concrete base in a concrete chamber, and is simply a section of 10-inch pipe with a valve at base, which is opened against pressure. A pilot valve which by-passes water around the main valve, filling the hydrant and equalizing pressure against both valve faces, is employed to make this practicable. The upper end of the hydrant is constructed to receive the portable head, which is attached and fastened to it with a slight turn, taking but a few seconds, and when not in use each hydrant is concealed under a sidewalk cover, thus being entirely out of the way.

This portable fire hydrant head was designed and made by the Ross Valve Manufacturing Company, of Troy, N. Y., to meet the requirements of the Baltimore specifications, viz.:

The Head.—The head, complete with cap not to weigh more than 110 pounds, and shall have five (5) openings, all fitted to receive Baltimore standard hose couplings. Four of the above openings to be fitted to receive 2½-inch hose couplings, located on the side of the head, spaced equally around same, and centre of each of side openings to be about 10½ inches above street or sidewalk

surface when head is in place. The fifth opening shall be fitted to receive 3-inch hose coupling and be located on top of head, and shall be used for the purpose of attaching a monitor nozzle, valve or hose, and be closed by a cap. The head shall be fitted with suitable grab handles, which shall be so placed as to balance the head. The openings shall be numbered from one to five, and such numbers shall be placed in a conspicuous place and finished in white enamel. Each head shall also have a number commencing with No. 10, these latter numbers to be not less than 3 inches in height.

combination operating and regulation valves, each capable of adjustment from shut-off as follows: 50 lbs., 75 lbs., 100 lbs., 125 lbs., 150 lbs., or the full pressure, if desired, up to 300 lbs. The pressures herein specified shall be marked clearly on valve by notches, so that the operator can use same as a guide in setting the regulating handles. Regulators must hold the pressure steadily and within 10 pounds of the set pressure, whether the play pipe is closed or open, and shall be provided with a locking device which will not permit the setting of same to a greater pressure than 150 pounds

HIGH-SERVICE MOTOR-WAGON FULLY EQUIPPED, SHOWING PORTABLE HYDRANT HEAD

Base of Head.—The base of head shall be so constructed as to fit hydrant: as installed for Baltimore high-pressure fire service. A drop latch shall be provided to lock the head in place after same has been properly placed in hydrant. Base of head shall be fitted with a moulded rubber ring.

Regulation of Openings.—The four side openings shall be fitted with

without unlocking; but after same has been unlocked it can then be opened up to 300 pounds. When wide open under the maximum pressure, the valves shall not show a loss of head of over 15 pounds. A suitable operating handle and pet cock shall be attached to each valve, the pet cock to be used for attaching a gauge, one gauge to be furnished with each head.

To meet these specifications a light bronze casting was fitted with special Ross combination operating and regulating valves, controlling each of the four 2½-inch hose outlets. These are numbered 1, 2, 3 and 4, respectively. The operating handle is provided with a lever and catch, which registers with notches in the cap of valve. These notches are graduated to indicate the pressure carried. An air cock on each opening is provided for a gauge and the fireman in charge of the head at a fire has a gauge he can attach at any time to test the pressure of any of the streams. When operating handle is turned full to the right, water is shut off; turning it to the left turns on the water, and to the pressure desired, by allowing the catch to drop in the proper notch. A lock is also provided to prevent pressure greater than 100 to 125 pounds being put on a line without first having orders from the chief in charge. When unlocked, and the handle turned full to the left, the full hydrant pressure of 300 to 350 pounds is obtained. The lock makes it perfectly safe to handle hose on ladders or inside of building, and also permits shut-off nozzles to be used on any 2½-inch line. The 3-inch opening in top of head is designed to permit the use of a deluge or special spray nozzle. It also permits 3-inch lines to be connected and laid a considerable distance beyond the present high-pressure mains, thus extending the high pressure fire zone. No regulation is attempted on this opening. Full hydrant pressure only would be used. This opening is ordinarily covered with screwed cap. Two grab handles are provided, one of which plainly shows in cut. One man can readily lift the head, and the cover having first been removed from the flush hydrant, he drops it in position. A latch shown on side of head holds it in place. The main hydrant valve is then opened. The connection to hydrant is 10-inch, and is made much quicker than the ordinary 2½-inch hose connection can be attached to a hydrant. The heads are carried on the hose wagon or auto truck with the hose and other fire-fighting apparatus. Only a few heads are required to equip the entire department, while the stand pipes or flush hydrants to which they can be attached may be numbered up in the thousands. This head has fully met the most exacting tests, and Chief Emerich and his assistants are unstinted in their expression of approval.

The National Board of Engineers speak as follows of this head and its uses:

"The type of hydrant is unusual, for such service, but it appears not to increase the time consumed in getting into action at fires; it is believed that the system of inspections adopted and the steps taken to secure familiarity with locations will result in hydrants being quickly found, and the ease with which heads can be attached removes one of the main objections to the use of flush hydrants. The separate head permits of the use of regulator valves permanently attached, thus giving excellent control of the pressure on hose lines. The hydrant and head under test show a sufficiently low friction loss, except in the screen, the use of which is not necessary; the regulators increase the loss materially, but not sufficiently to lessen fire protection, unless too great a quantity is taken from one outlet.

"Test of the hydrant head indicated a loss in the outlet and the regulator valve equivalent to about 10 pounds for a flow of 300 gallons a minute from a single outlet, 20 pounds for 500 gallons, and 25 pounds for 600 gallons; these cannot be considered excessive losses. The hydrant heads have been provided with a screen to catch coarse material; the tests showed that these became clogged and introduced a very high friction loss, amounting to 30 pounds for 2,300 gallons a minute flowing; as these screens are not necessary to the operation of the hydrants, their removal is advisable.

"Upon arrival of the hose wagon, two men, with hydrant head and

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KANSAS CITY, MO.

key, run to the hydrant; one man removes the cover, which, if stuck, can be easily broken; the other places the head in position, and, by a slight turn, locks it into position. Water is turned on with the key and hose attached to one or all outlets; by means of the regulators on the head any desired pressure can be given each line up to full pressure without calling up the pumping station.

"Tests made showed that, starting from the middle of the street, two men could remove the hydrant cover, place the head in position and turn on the water in 18 to 25 seconds."

The Ross Valve Manufacturing Company is also making an independent combination of operating and regulating valve that can be attached to any high-pressure type of hydrant. This valve protects the fireman and enables shut-off nozzles to be used on any high-pressure line.

We are indebted to *Insurance Engineering* for the use of the illustrations on pages 51 and 61 showing the Ross hydrant head.

THE largest European manufacturers of machinery and tools for making dies for metal stamping, cutting and punching, seek a representative for the United States. The applicant must have scientific training and command of German Language. Answers, in confidence, to be addressed to Esemsco, P. O. Box 822, N. Y. City.

AN INTERESTING GROUP OF EMPLOYEES AT A PITTSBURG PLANT

THE unique group shown above consists of twenty-nine representatives from twenty-five different colleges located in nineteen different States of the Union, and is made up of members of the engineering faculties of several of the most important technical schools in the United States. These men, believing the most effective way of learning the practical side of engineering and fitting themselves to instruct their students was to engage in the work themselves, gave up their vacation periods, came to Pittsburg, entered the employ of the Westinghouse Electric & Manufacturing Company, and engaged in actual manual labour, manufacturing the various types of electrical apparatus produced at the East Pittsburg works of said company.

The company officials were anxious to co-operate with the professors and to encourage the closer union between the educational institutions and manufacturing concerns. With this idea in view, they offered them a special course in training in the works. They are engaged as regular employees, and are assigned check numbers, the same as other employees. By engaging in this work these men are enabled to become familiar with the new apparatus as it is brought through the works, and, furthermore, to get the industrial viewpoint in a manner that otherwise could not be obtained. This experience also enables them to learn first-hand just what the young men whom they are educating will be expected to do and wherein the educational methods should be improved. At the same time, the company gets the viewpoint of the college men, all of which tends toward a closer co-operation between the colleges and the factories.

The course includes regular work in the shops, and, in addition, inspection trips after working hours to in-

(Continued on page 73.)

Investing Your Money

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SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

AT no time since the fall season opened has business prospects appeared brighter than they do at this writing. The stories that come to us from business centres and the agricultural districts are all of the "much-better-than-expected" order.

The most authentic estimates on the cotton and wheat crop place the season's yield of these two staples at unusually high figures. The Government's reports indicate that we will have at least 14,500,000 bales of cotton, and one of the most trustworthy of the country's private crop experts prophesies that our wheat crop will reach 752,000,000 bushels, which is 50,000,000 bushels in excess of the Government's estimate.

The industrial situation is in first-rate shape. This is especially true of the iron and steel trade. While all of the railroad earnings are exceptionally large, it would seem that the hard coal roads have been most prosperous. As an example, it is stated, upon dependable authority, that the Lehigh Valley in the first three months of its fiscal year earned the entire semi-annual dividend on its stock.

The securities market is reflecting the general tone of prosperity, with the result that stocks are more buoyant to-day than at any time during the past year. The most encouraging feature in connection with the advance in stocks is the fact that, in the majority of instances, advances have been justified by increased earnings.

When we consider that this state of prosperity exists in spite of the highly-seasoned Presidential campaign, it forces the conclusion that, fundamentally, the country is sound, and it further shows that the nation's strength has not been enfeebled or the morality of its citizenship sapped by the corporate and Government ills with which it has long been beset.

It is evident that to-day healthier conditions prevail in all lines of trade than at any time during the past five years. This is due, in a large measure, to the fact that higher ideals have been brought out, both in business and politics.

Men may differ as to who has the most to do with dissolving the unwholesome partnership between political bosses and business interests, but the fact remains that the dissolution is taking place and illegitimate practices in commercial life are being destroyed. No one political party can rightfully claim all of the credit for this improved condition, as the credit is really due to the people

themselves, regardless of party affiliations, in whom there has been awakened an irresistible desire for greater freedom and fair play, both in government and in business. They will get it, and, what is more, they deserve it.

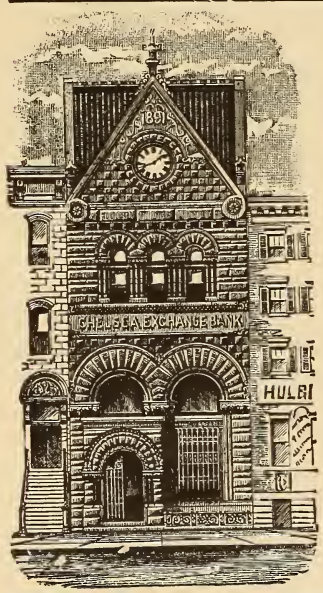
Question—What do you think of withdrawing money from the savings-banks for the purpose of buying a good stock on margin?

Answer—It does not matter how good the stock is; we do not believe it is advisable to withdraw savings from a bank for the purpose of purchasing stocks on margin. This is a form of gambling in which only the rich can afford to indulge.

The Dodge Manufacturing Company has opened a branch store and warehouse at Fourteenth and Lovejoy streets, Portland, Ore., where a complete stock of Dodge power transmission machinery and appliances will be carried in stock. The branch will be under the management of Charles A. Barnard, formerly vice-president of the Barnard & Meas Manufacturing Company, Peoria, Ill., and an engineer of wide experience in mill equipment. Besides the Dodge line, the Portland branch will have the Northwestern sales agency for the well-known line of flouring mill machinery manufactured by the Wolfe Company, Chambersburg, Pa. Mr. Barnard's wide experience in the design and manufacture of flour mill machinery, elevating, conveying and power transmission machinery insures to the mills and other power-using plants of Oregon and Washington a real service in an engineering capacity on their requirements in these lines.

This makes the tenth branch opened by the Dodge people, and Portland is added to the list in pursuance to a

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

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demand. Branches are now maintained at Minneapolis, Philadelphia, Pittsburg, Chicago, St. Louis, Atlanta, Cincinnati, New York, Boston, and in connection with these several hundred dealers throughout the country carry the full line in stock.

Since their segregation early last December, and including the three-quarters of the present year ended September 30, the former subsidiaries of the Standard Oil Company of New Jersey have paid $37,892,925 in dividends, exclusive of stock disbursements. Including the dividends already declared, but upon which payment falls due in the last quarter of 1912, the total of dividends amounts to $39,817,925. Cash dividends for the first six months of the calendar year amounted to about $23,000,000.

Question—Do you consider railroad stocks good investments at the present time?

Answer—Taking railroad stocks in general, we believe they offer exceptional opportunities for profitable investment. There are a few whose earnings have been particularly good. We have previously advised the purchase of St. Paul, since which time the stock has advanced several points, and we still believe it a good purchase at prevailing prices.

Bigger bank clearings, expanding trade and active building construction are usually marks of prosperity. Bank clearings for 1912 up to August 31 were $113,582,872,000, against $105,728,996,000 for the same months last year. Exports for the first three-quarters of 1912 are already $157,000,000 more than the entire

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year of 1911. The Debenture Corporation of New York (334 Fifth avenue), in a recent Real Estate Market Letter, estimates that during the first eight months of the year, in the principal cities of the United States, $591,852,000 was expended in building construction.

Question—Would you advise one of small means to purchase Southern or Western fruit and pecan orchards on the installment plan?

Answer—As a rule, such investments are highly speculative, and we believe the small investor would do much better by purchasing good preferred stocks, many of which will net him 6 per cent. or better.

The American Car & Foundry Company will, in all probability, benefit by the present car shortage through large orders for new cars. This company is working at full capacity now and is making big profits.

Question—What do you think of the copper stocks condition?

Answer—The better copper stocks during the past year have shown excellent strength, and we are inclined to favor such stocks as good business investments. Copper stocks, however good, should never be regarded as appropriate investments for savings. We rather expect to see many of the copper shares listed on the Boston and New York Exchanges substantially advance between now and the first of the year.

The value of the brick, tile, terra cotta, pottery and various other clay products made in New York in 1911, according to the United States Geological Survey, was $10,184,376. This is a decrease of $1,687,573 as compared with the figures for 1910.

The annual report of the International Agricultural Corporation shows net earnings, exclusive of interest, of $2,031,209. The surplus, after payment of interest on bonds, other obligations and dividends on preferred stock, was $551,008.

The Delaware and Hudson Company

NOTICE TO MANUFACTURERS

This railroad extends from the coal fields of Pennsylvania to connections with all the great railroads of Canada and the Eastern trunk lines; provides a fast freight service to the East, West, North and South and parallels the upper Hudson River, also the new two thousand ton barge canal, now being built by the state, connecting the Hudson River with Lake Champlain. An establishment located in this territory receives the benefit of cheap fuel, electric power and low freight rates.

Its Industrial Department will aid in the establishment of industries, develop side track questions and give complete information.

IRA H. SHOEMAKER

ALBANY, N. Y. Industrial Agent

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With the exception of China and the Orient, American musical instruments are gaining favour in foreign markets. However, the Chinese like our phonographs, because they are easily adapted to selections in any language. Oriental shopkeepers were quick to recognize the value of the phonograph as a crowd-gatherer, and many stores have a phonograph playing in front all day long.

The American Telephone and Telegraph Company reports for the year gross earnings of $18,534,249, an increase of $859,842, and net earnings of $9,669,845—an increase over last year of $329,727.

The larger return of preferred stocks over seasoned bonds is drawing the attention of many conservative investors. Preferred stocks, backed by good earnings of a sound institution, are selling readily. Those who in the past have been satisfied with 4 or 4½ per cent. are now demanding 5 or 6 per cent. for the use of their money.

Peat Production Small

While the United States is rich in peat deposits, the amount produced is small, that for 1911 being only 64,165 short tons, valued at $311,486, according to figures compiled by Charles A. Davis and just made public by the United States Geological Survey. By far the greater part of this production was used in the fertilizer industry, 51,733 tons being utilized for that purpose.

In 1911 there was a growing consumption of peat for miscellaneous uses, the most important of which seems to have been the use as an absorbent for refuse beet sugar and other molasses, so that these excellent feeding materials can be fed economically to cattle and other live stock. Charred dried peat is also used in poultry food and other commercial foods for stock.

A copy of the report may be obtained free on application to the Director of the Geological Survey, Washington, D. C.

An Interesting Group of Employers

(Concluded from page 65.)

spect the various pieces of apparatus. These tours are under the guidance of the engineers who design the various pieces of apparatus inspected.

As an indication of the earnestness with which these men are following their work it is interesting to note that although these trips are taken after working hours and before the evening meal, yet the attendance has averaged 90 per cent. of the men on the course.

Regular meetings have been held in the evenings at the rooms of the Westinghouse Club, in Wilkinsburg, where a general discussion has been indulged in and interesting talks have been given by the various officials of the Westinghouse Electric & Manufacturing Company.

The following men are enrolled in the course:

R. M. Berry, Virginia Polytechnic Institute, Blacksburg, Va.

W. D. Canan, Pennsylvania State, State College, Pa.

R. F. Chamberlain, Cornell, Ithaca, N. Y.

A. T. Childs, University of Maine, Orono, Me.

Myron Creese, Maryland Agricultural College, College Park, Md.

F. T. Dargon, Slemsen College, Clemsen, S. C.

F. B. Davenport, Georgia School of Technology, Atlanta, Ga.

L. A. Dogett, Harvard University, Cambridge, Mass.

S. P. Emrick, Purdue University, Lafayette, Ind.

W. A. Folger, University of Pennsylvania, Philadelphia, Pa.

E. S. Foster, Lehigh University, South Bethlehem, Pa.

W. B. Gladson, University of Arkansas, Fayetteville, Ark.

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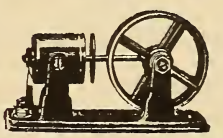

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Journal
of the
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of
ENGINEERING
SOCIETIES

Bridge Foundations in the Columbia and Williamette Rivers, near Portland, Oregon
By RALPH MODJESKI
Oregon Society of Engineers.

Flood Protection for Mississippi Valley: A Symposium
By C. O. SHERRILL, W. E. KNOBLOCH
A. PERRILLIAT, W. B. GREGORY
A. M. SHAW, S. F. LEWIS, F. M. KERR
G. H. DAVIES
Louisiana Engineering Society.

JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES
SEPTEMBER, 1912
30 cents per copy $3.00 per annum
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F. A. Robinson, Iowa State College, Ames, Ia.

E. B. Stavely, Columbia University, New York City.

G. B. Thomas, Colorado College, Colorado Springs, Col.

R. W. Witham, Worcester Polytechnic Institute, Worcester, Mass.

B. A. Wooten, Alabama Technical Institute, Auburn, Ala.

An important paper, entitled "The Commercial Development of Chemical Processes," was presented by Mr. Jasper Whiting before the Eighth International Congress of Applied Chemistry, held at New York, September 10, 1912. Those who would like a copy of this paper can obtain one by addressing Mr. Whiting, care of the Chemical Engineering & Operating Company, 89 State street, Boston, Mass., and mentioning this notice in CASSIER'S MAGAZINE.

Accidents Which Might Have Been Prevented

Under this title there has been issued by the Industrial Commission of Wisconsin a most interesting bulletin, a copy of which can be obtained by writing Mr. Paul J. Watrous, Secretary, Madison, Wis. Another interesting bulletin issued by the same commission is one entitled "Workmen's Compensation."

THE LATEST CATALOGUES

The General Electric Company has designed and standardized switchboard panels which long experience and accurate knowledge of requirements have demonstrated will successfully meet the demands for which they are intended, and has just issued two bulletins, one illustrating and describing alternating-current switchboard panels for three-phase, three-wire circuits, of 240, 480 and 600 volts, 25 to 60 cycles, and the other describing direct-current switchboards, double polarity, 125, 250 and 600 volts. These bulletins are numbered 4996 and 4995, respectively, and will be sent on request to those who mention CASSIER'S MAGAZINE when writing for them.

Mallet Articulated Locomotives

An exceedingly interesting description of the Mallet type of articulated locomotives, the most successful type of such locomotives now in use on American railways, is given in a new publication issued by the Baldwin Locomotive Company, of Philadelphia, Pa.

This work contains, in addition to an exceedingly clear description of this type of locomotive, fully illustrated, pictures and descriptions of a few of the many such locomotives the Baldwin Locomotive Company has built for American service, among others for the Lake Terminal Company, at Lorain, Ohio, where, due to track conditions, the service required is most severe; Chicago Great Western Railway, who now have in use ten locomotives of the Mallet type; the Carolina, Clinchfield & Ohio Railway; Atchison, Topeka & Santa Fé Railway Company; Southern Railway Company; Southern Pacific Company; Virginian Railway Company; Duluth, Missabe & Northern Railway Company, and St. Louis, Iron Mountain & Southern Railway Company.

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Duryea System of Automobile Construction

The Duryea Motor Company, of Saginaw, Mich., have just issued a booklet written by Mr. Charles E. Duryea, which is a contribution of real value to the literature of automobile engineering. In the July number of this magazine appeared a short article descriptive of the "Duryea System of Motor Vehicles," which attracted much attention; but our readers will find this new booklet

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It is not required that you purchase a pen to get this Safety Holder. We simply want the names of dealers who do not handle this pen that we may mail them our catalogue.

We will appreciate this favor very highly.

Address,

Laughlin Mfg. Co.
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Detroit, Mich.

contains a much fuller description than space permitted in this magazine.

The Duryea Company will be glad to send a copy on request to those mentioning CASSIER'S MAGAZINE.

Pumping Water by Compressed Air

"Water Lifted by Compressed Air" is the subject of a 70-page, 6 x 9 catalogue, Form 75, just issued by the Ingersoll-Rand Company, No. 11 Broadway, New York City.

During recent years much progress has been made in the art of pumping water by compressed air. The air lift has proven especially useful for city and town water-works, asylums, hospitals, plantations, railway water tanks, irrigation, private country homes, pumping mines, ice manufactories, breweries, cold storage and packing houses, textile mills, dye-works, bleacheries, sewerage installations, dry docks, seaside water-works, stock farms, etc.—in fact, anywhere and everywhere that clear and abundant water is needed.

In this catalogue the Ingersoll-Rand Company explain very thoroughly the different methods employed, and give figures showing actual cost of operating various installations.

The air lift involves the use of an air compressor located where the expense of attendance is least; an air receiver adjacent to this compressor; a pipe line for conveying the air from the receiver to the wells; one or more wells drilled to a depth proportionate to the height of the lift and the depth of the water strata below the surface; air and water pipes running down inside of these wells; the proper proportion of their vertical length being submerged when at work, representing the pumping apparatus proper.

Catalogue is profusely illustrated, to show the workings of the different systems.

The Pedestal Pile

"The Pedestal Pile." A new edition of this book has just been issued by the MacArthur Concrete

Pile & Foundation Company, 11 Pine street, New York, from whom a copy may be obtained. In its general layout this book is the same as the first edition, but it contains a number of illustrations and descriptions of work recently completed and also other additions to the text.

This book contains much valuable data on the bearing power of soils, frictional resistance, etc., and a complete description of the pedestal pile and how it is constructed.

Hand Hammer Drills

"Bulletin, Form 4017," describes a new line of "Butterfly" hand hammer drills manufactured by the Ingersoll-Rand Company, 11 Broadway, New York City. These drills are adapted for such work as pop shooting, breaking up boulders, trimming walls, and all work requiring holes not exceeding 5 feet in depth.

This catalogue illustrates various types and sizes as built, and a sectional view on the last page shows the duplicate parts.

A copy will be sent on request to those writing the Ingersoll-Rand Company and mentioning CASSIER'S MAGAZINE.

High-Pressure Coverings

"Nonpareil High-Pressure Coverings." The Armstrong Cork Company, Pittsburg, Pa., have issued an exceedingly attractive and most interesting book descriptive of Nonpareil high-pressure coverings for high-pressure and superheated steam lines, boilers, breechings, and all heated surfaces.

It is claimed for the Nonpareil high-pressure coverings that they are more efficient non-conductors of heat than any coverings heretofore in general use, and that they will withstand temperatures at which the older coverings will calcine and disintegrate; and, further, that they posess much greater moisture-resisting power and are just as easy to apply and equally reasonable in first cost. The hand can be held against one side of a

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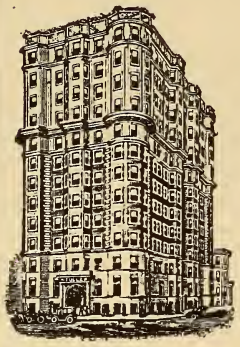

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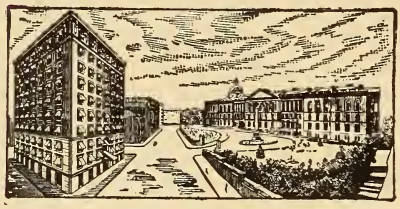

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STORER F. CRAFTS, Proprietor

piece of Nonpareil high-pressure covering without discomfort when the other side is white-hot.

This book contains the report of Mr. William J. Baldwin, M.E., on the results of the condensation experiments with Nonpareil high-pressure pipe covering; the report of Mr. A. W. Morse, M.E., of tests of the same pipe covering, and also the report of a fire test made upon samples of this covering by Mr. Ira H. Woolson, consulting engineer of the National Board of Fire Underwriters, New York.

The book contains valuable information and data and is most completely indexed. It will be sent free to anyone writing the Armstrong Cork Company, Insulation Department, and mentioning CASSIER'S MAGAZINE.

"Manila Rope." A brief treatise for engineers on ropes used for the transmission of power, together with formulas, tables and data useful in mill engineering, by C. W. Hunt. This work contains several most interesting illustrations of early rope making and power transmission, with description of same. One illustration, for instance, shows Assyrian workmen in the age of Osirtasen II., the contemporary of Joseph, between 1652 and 1636 B. C., engaged in moving a large sculpture by means of ropes, and is used to illustrate ancient rope transmission. Another interesting and useful feature is a table of technical words relating to cordage, and the advantages of rope for power transmission are clearly given by text and illustrations.

The book also contains chapters on "Splicing Transmission Rope," "Rope Couplings," "Knots, Hitches, Bends," "Hoisting Rope," "Rope Driving," "Working Loads for Manila Rope," "The Manila Fibre Industry," etc.

This book is issued by the C. W. Hunt Co,, of West New Brighton, New York, and a copy can be obtained by addressing them and mentioning CASSIER'S MAGAZINE.

Selection of Boiler Feed Water

"The Selection of a Boiler Feed-Water" is the title of a paper by Mr. J. C. Wm. Greth, presented before the Engineers' Society of Western Pennsylvania and now issued as a separate pamphlet by Wm. B. Scaife & Sons Company, of Pittsburg, Pa. This is an exceedingly valuable paper on this most important subject, and contains information of the greatest value to engineers and chemists, who are frequently confronted with the question, Will the water of a certain analysis prove to be a boiler-feed supply which will neither scale nor corrode?

Among other subjects treated may be mentioned: "Effect of Evaporation on Impurities," "Mistaken Conclusions Regarding Sodium Salts," "Effect of Impurities," "Conditions Governing Character of Scale" and "Water Softening and Purifying."

To all interested in the question of obtaining a satisfactory water for boiler-feed use this work will prove of great service, and they should write for a copy, which Wm. B. Scaife & Sons Company, of Pittsburg, Pa., will send on request to those who mention CASSIER'S MAGAZINE.

Earliest Production of Steel

The first steel produced in this country was probably made in Connecticut in 1728 by Samuel Higley and Joseph Dewey. Crucible steel was first successfully produced in the United States in 1832 at the works of William and John H. Garrard, at Cincinnati, Ohio. Bessemer steel was first made in this country in September, 1864, by William F. Durfee at an experimental plant at Wyandotte, Mich., and open-hearth steel in 1864 by the New Jersey Steel & Iron Company, at Trenton, N. J.

The Institute of Operating Engineers held a most successful meeting on September 6 and 7 at the Engineering Societies' Building in New York.

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You *can*—if you really want to. You can fit yourself to earn *more* than the other fellows. For they are not naturally any smarter than you. They haven't any more brains or ambition than you. They don't work any harder than you. They are simply *trained men*—that's the difference. They have *special knowledge* that you don't possess—*special knowledge* and *training* that makes them *worth more* to their employer than you can possibly be until *you* equip *yourself* with special knowledge and training.

The American School is training *hundreds* of men to become draftsmen, engineers and architects. It is training hundreds to fill executive positions, to earn *good* salaries, to play a man's part in the business game. *And what the American School of Correspondence is doing for others it can do for you.*

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A Split Iron Sheave Weighing 45,000 Pounds

An indication of the unlimited scope of the Dodge Manufacturing Company in all matters connected with power transmission was recently strongly emphasized at their works when a split iron sheave, 288 inches (24 feet) pitch diameter, with a 40-inch face width, was cast in the south foundry of their plant at Mishawaka, Ind., under the direction of Mr. Harry Bell, superintendent of their foundries.

It required about ten days for the foundrymen to shape up the big mould, about two hours to prepare for the pour, and a little over two minutes to pour the metal—approximately 53,000 pounds. The metal was distributed by means of immense ladles through a runway over the mould.

The wheel, when finished, will weigh about 45,000 pounds. It was made for the Anaconda Copper Mining Company, Anaconda, Mont., for use on the shaft of a 46 x 60 Duplex blowing engine. It is grooved for twenty 1⅜-inch Dodge "Firmus" manila ropes, has a 16-inch bore, and will be driven by another sheave, 48 inches diameter on a 750 H. P. motor at 59 revolutions per minute.

The large wheel was cast in two sections, and will be shipped in that condition. After it leaves the machine shops at the mines the halves will be fastened together permanently, not only by bolts, but through rim lugs.

Several years ago the company made a large wheel for the Kokomo (Ind.) Steel & Wire Company. This was also 24 feet in diameter, 7½ inches face width, and weighed 80 tons. It was of four-piece construction, consisting of two split pulleys bolted together by internal rim flanges.

This wheel, which, like the one recently produced, was cast under the direction of Mr. Harry Bell, and goes to prove their claim of years that no job can come too big and none too small for the machine shops and foundries of the Dodge Manufacturing Company.

Needed by Many Technical Advertisers

An evidence of the increasing attention being given to the most efficient methods of advertising marketing engineering and technical products appears in the announcement of the formation of Wightman & Richards, Technical Department of Jos. A. Richards & Staff, General Advertising Agents, Tribune Building, 29 Broadway, New York City, representing the association of Joseph A. Richards, Lucius I. Wightman and Paul Morse Richards.

Mr. Joseph A. Richards is the head of the agency having his name—founded by Joseph H. Richards in 1872, and since identified with some of the most conspicuous national successes in advertising salesmanship. Mr. Wightman is an engineer, who has for many years specialized in the advertising and marketing of machinery and engineering products, and brings to the association several important technical accounts. Mr. Paul Morse Richards is a publisher, sales manager and advertising man of wide experience, until recently with *Motor World,* and prior to that advertising manager for *Power* and other technical journals. His extended experience will aid in the conduct of advertising, selling and marketing campaigns.

Wightman and Richards bring to the field served by the technical press that much-needed combination of agency facilities with specialized technical and engineering skill. Their cards bear the singularly descriptive caption, "Counsellors and Consulting Engineers in Technical Advertising and Marketing." The scope of their service covers every proved method of legitimate sales-increasing and business-building—direction and preparation of advertising and advertising literature, mailing lists, sales campaigns, marketing plans, and the organizing and systematizing of advertising departments.

The association is formed in recognition of the fact that advertising is salesmanship, and that the most efficient marketing of any product demands a unifying, rather than a separation, of advertising and selling efforts. The union of the three seasoned principals in the new organization guarantees, through specialized service, a judicious administration of any account, whether in the general or technical field, combining, as it does, an experienced advertising manager, an engineer and a sales manager, with a complete corps of trained assistants.

A number of exceedingly interesting papers were presented before the American Institute of Metals at their convention in Buffalo September 23 to 27 last. Those desiring information concerning this society should address Mr. W. M. Corse, secretary, care Lumen Bearing Company, Buffalo, N. Y.

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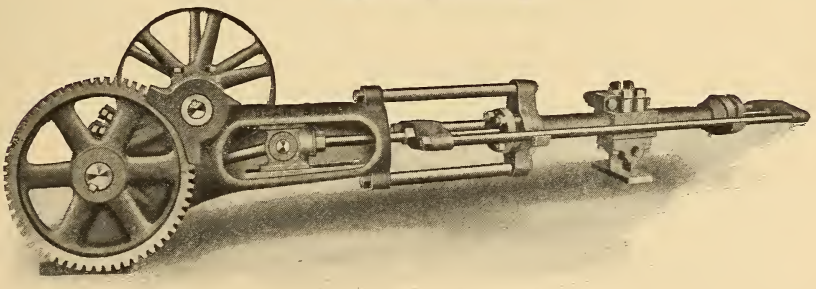

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SEND FOR CATALOGUE No. 84

The ISOLATED PLANT

175,000,000 Tons of Coal Wasted in the United States Every Year

Read the Article by Warren H. Miller

The Conservation in Power Resources

IN THE JULY ISSUE

Mr. Miller spent three years travelling through nearly every civilized country with no other object than the investigation of power units, and their fuel consumption, and he returns to tell us that we are wasting this tremendous fortune in fuel every year. You will be interested to know how we are doing it.

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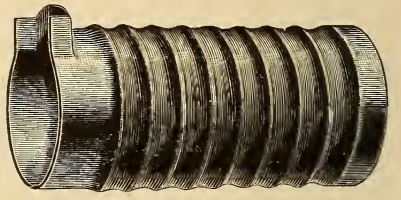

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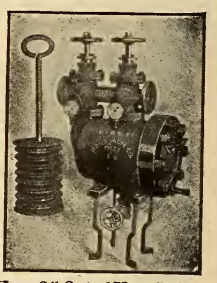

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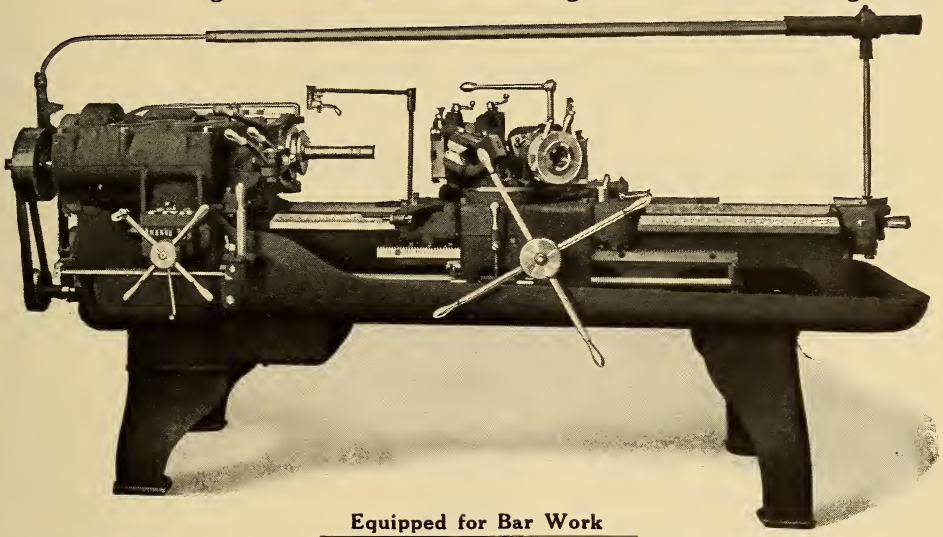

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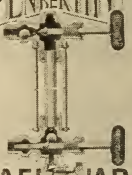

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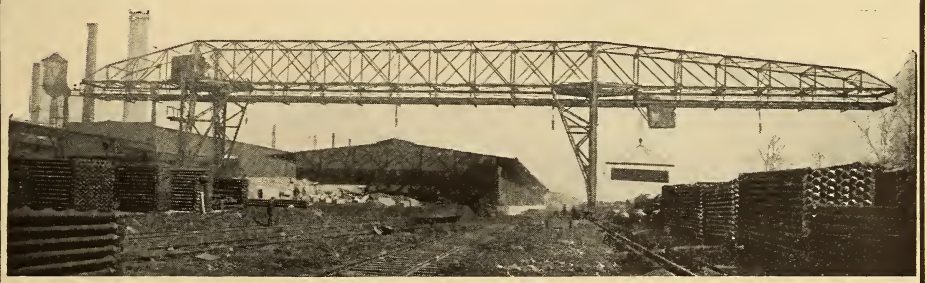

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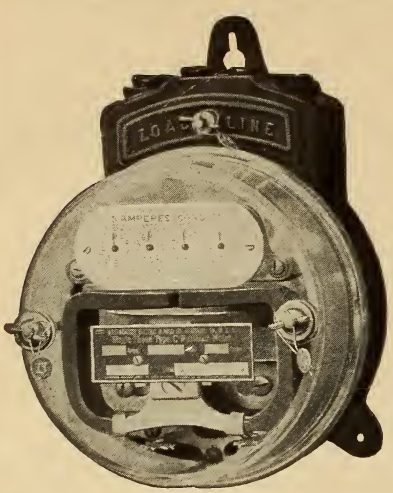

TYPE C
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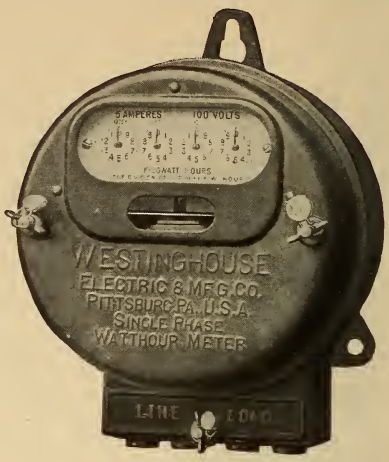
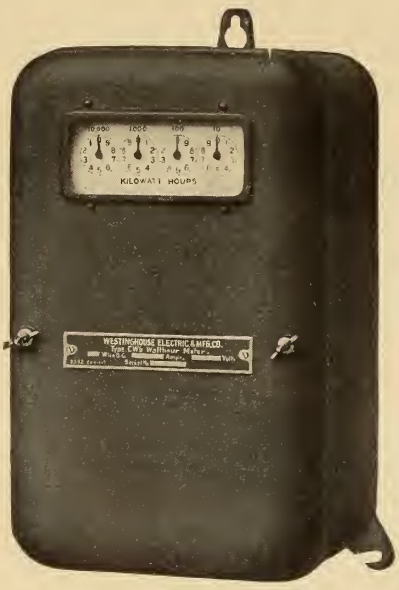


TYPE OA
Alternating Current
Bottom Connected, Left Hand Feed

Westinghouse Watthour Meters



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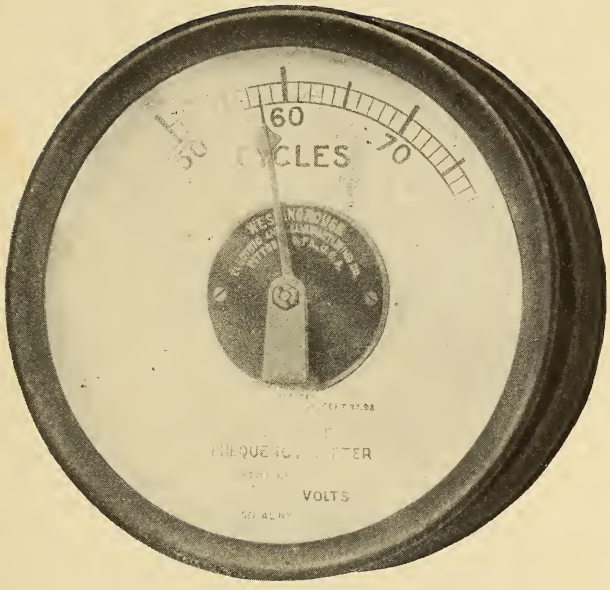


NEW TYPE OF FREQUENCY METER

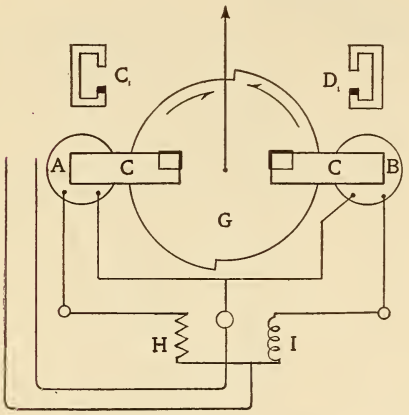
NEW TYPES OF FREQUENCY METERS

By William Swift

FREQUENCY METERS are extremely useful switchboard appliances, as they indicate immediately any variation in the speed of prime movers. By their use, irregularities in the operation of engine or waterwheel governors may be readily detected and immediately brought to the attention of the operator so that adjustments can be made. On circuits that supply induction motors driving textile mill and other machinery requiring constant speed constant frequency is essential, and the installation of a frequency meter will constantly indicate the speed being maintained. In the central station supplying power and lighting service the maintenance of normal frequency is equally important. Many watthour meters now on the market are adjusted for a particular frequency, and register slow if the frequency is either below or above normal. A meter that will indicate a variation from normal frequency, therefore, tends to prevent this loss of revenue.

The Westinghouse frequency meters, two new types of which are here illustrated, indicate the frequency accurately by means of a continuous scale and pointer, whereas meters that operate by means of resonance reeds, or similar devices, have only a definite number of possible indications, and intermediate points are entirely lacking.

The meter consists, as will be seen from the detail illustration, of two induction voltmeter elements, *A* and *B*, acting on a disk *G*, and tending to move the disk (and the pointer shaft) in opposite directions. One of the elements is in series with a resister *H* and the other in series with a reactor *I*, so that any change in the frequency tends to change the relative strength of the two magnets and cause rotation. The disk is so shaped that, as it moves, the amount of its metal under the strongest magnet becomes less than that under the weaker magnet, so that with every relation between the two magnet strengths there is some point where the torques produced by the two magnets balance and the pointer comes to rest. Magnet *A* tends to turn the disk in clockwise direction and magnet *B* in the opposite direction.



DETAIL OF FREQUENCY METER

The torque of each magnet is proportional to the square of the current in the coil and to the frequency. At normal frequency the torques balance when the disk is in the middle position. If the frequency increases, the current in coil *A*, which is in series with resistance only, remains unchanged and its torque increases because of the higher frequency; the current in coil *B*, which is in series with reactance, diminishes, and its torque diminishes accordingly. The disk, therefore, turns toward the right. For similar reasons, if the frequency decreases the disk turns toward the left.

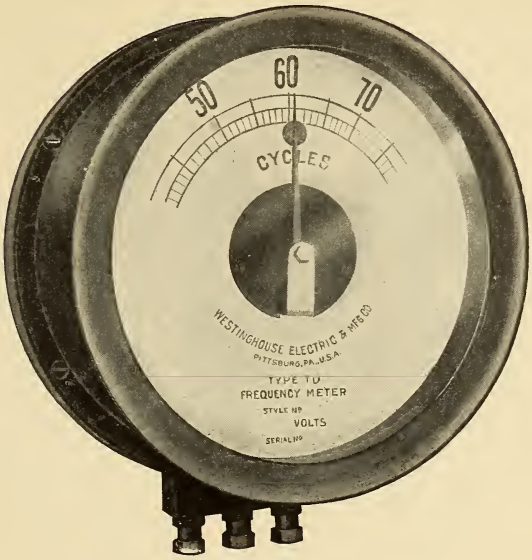
If the periphery of the disk were a true circle any change in frequency which would cause the torques of the two magnets to be unequal would produce continuous rotation in one or the other direction. The disk is, therefore, made of a special shape. The left-hand edge of the disk, which moves under magnet *A*, is practically the arc of a circle, having its centre at the shaft. The right-hand edge, which moves under magnet *B*, is practically the arc of a circle, with its centre slightly above the shaft. With this arrangement, the amount of metal in the air gap of *A* is always practically the same, while the amount of metal in the air gap of *B* depends on the position of the disk. When magnet *B* becomes relatively stronger than *A*, owing to low frequency, the disk turns toward the left, and the amount of metal in the air gap of *B*, and consequently the torque of *B*, gradually decreases until the torques of the two magnets balance, when the disk stops. When magnet *B* becomes relatively weaker than *A*, owing to high frequency, the disk turns toward the right, and the amount of metal in the air gap of *B*, and consequently the torque of *B*, gradually increases until the torques of the two magnets balance, when the disk stops. For every frequency there is a definite point at which the disk comes to rest.

As actually constructed, the edges of the disk are not true circular arcs. The shape is determined experimentally, so that a uniform scale will result.

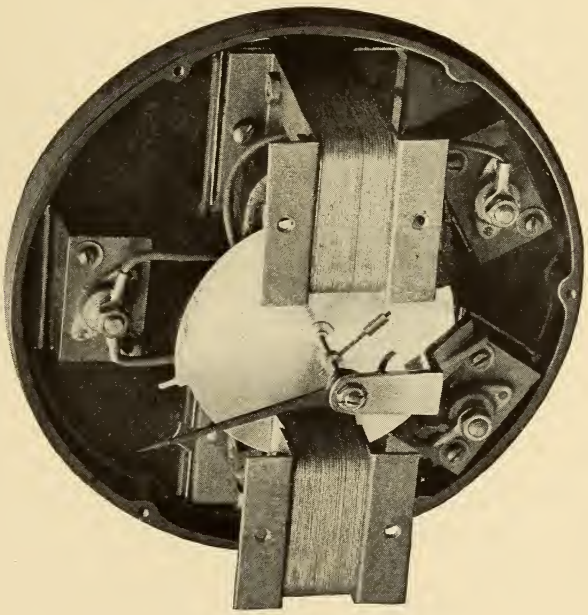
Any change in voltage applied to the two voltmeter elements changes the current in both of them in the same proportion, so that their relative torques are not changed. The meters are, therefore, unaffected by voltage changes within wide limits.

The moving element consists of

NEW TYPES OF FREQUENCY METERS



WESTINGHOUSE FREQUENCY METER



WESTINGHOUSE FREQUENCY METER

the meter disk, the pointer, a counterweight, and the shaft. This element is so balanced that the pointer will remain in any position when no current is on the windings. The pivots of the shaft, which are of specially hardened and polished steel, rest in jewel bearings. The entire moving element can be easily removed.

No control spring is used, as all the forces controlling the movement

(Concluded on page 63.)

Serving the Customer

ONE of the important things which makes for successful work in engineering is the proper choice of material. It might seem to be a simple thing to decide just which, among the various materials of construction, was the best for any given piece of work, but experience and observation will show that there is wide difference of opinion between men on this really important subject. Machines, tools, elements in entire systems of activity, intended for similar purposes and planned along similar lines, will be found using entirely different materials, indicating either distinct differences of opinion or else insufficient exercise of judgment.

In many cases this variation in the use of material may be seen to follow wholly different methods of work. Too often the designing engineer examines a problem solely from his own point of view, and fails to appreciate that he is not the only man who will have to deal with the case. To him the best material is the one which he can work most readily, or which lends itself best to structural purposes; he has the machine to build, and when it is out of his hands he sees it no more. Even if such a method is not followed intentionally, it may be the one which is naturally in the mind of the man who sees little of the performance of the product.

In other instances the character of material and method of design are governed by workshop limitations, including capacity of tools for certain purposes or by facilities for handling, and thus it will be seen that differences may arise from causes which do not always appear to the ordinary observer.

In the long run, however, the choice of material, as well as the details of the design, should primarily be governed by the actual use to which the completed article is to be put. It is made for service, and this service should be the controlling influence in the design. If this view can be made to work in with the best or most convenient constructive operations, so much the better; but it should always be remembered that the service should take precedence over the brief period during which the article is in the shop of the manufacturer.

An excellent example of the influence of the point of view upon the material is seen in the case of the manufacture of pulleys for the transmission of power by belting. It is true that the earliest pulleys were made of wood, but this was because of the limitations of shop facilities, and not from any perception of relative values. As soon as belt transmission became general the manufacture of pulleys followed upon a commercial scale, and pulleys were made of cast iron, a material by no means best adapted to the service, but one most readily available in the ordinary machine shop. Pulley making became mainly a foundry job, and the boring and turning followed as a matter of course. Even the proportions and strength of pulleys had to be based upon casting stresses rather than upon belt pull, although the latter was the real duty of the pulley and the former only an incident in manufacture. When the actual possibilities of wooden surfaces, so far as driving efficiency is concerned, were understood, and the advantages of light weight, interchangeability and other operative features were realized, the whole pulley question underwent a revision.

This is but a single instance, but it is one which is sufficient to show how desirable it is that the viewpoint of service should predominate in the design of any piece of machinery. The details relating to manufacture are important, and questions of shop limitations belong to every establishment; but these must follow, and not precede, the real and controlling features of any problem, the requirements of service, the performance which is to be given to the discriminating purchaser.

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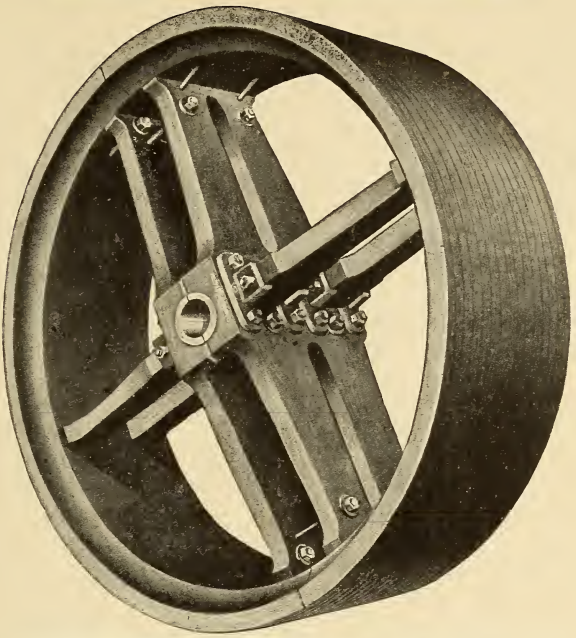

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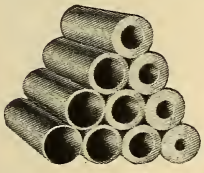

Dodge BushingSystem making the pulley available for all sizes of shafting.

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The other day in connection with an order for a new lot of these pulleys, John M. Studebaker, president of the corporation, and a man known for his honest convictions, took occasion to say:

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Efficiency in the Foundry

IT is a curious fact that progress in mechanical industry does not proceed according to any well established laws, but that it seems to act in an irregular manner, some departments of work lagging behind, while others keep in the lead.

It has always been a matter for surprise that the foundry, until recently, has failed to keep pace with the machine shop, and even to-day it is only in the more modern and better equipped shops that the department in which the castings are made is as far advanced as the department in which those same castings are finished.

To-day, however, the foundry is overtaking the other departments of the manufacturing establishment, and there is every reason to believe that the modern workshop is more nearly homogeneous than ever before, so far as character of equipment is concerned. The moulding machine, the overhead traveling crane, the industrial railway, the pneumatic rammer—these and other tools are fairly equal in capacity and value to the lathe, the planer and the milling machine.

When we consider the interdependence of the various departments of a manufacturing establishment, it seems strange that modern equipment did not enter the foundry earlier than it has. The study of the influence of each element in a series of operations in sequence has emphasized what was well known before, even if imperfectly appreciated—that the final efficiency is found by multiplying together the several efficiencies of the successive operations. Since the product of the foundry entered into nearly all the other departments of an establishment, it is evident that an inefficient foundry formed a serious handicap upon all the departments which it served, so that any improvement effected could not fail to be far-reaching in its influence.

There is probably no one element which has aided more in the advancement of the efficiency of the foundry than compressed air. Whether in the operation of machines for ramming moulds, for operating hoists, for serving moulding machines, or for cleaning castings, the presence of a supply of air under pressure has placed in the hands of the foundryman a source of power which has worked both for effectiveness and for efficiency.

Foundry work does not differ materially from other work in the extent to which the work of the brain may be supplemented by mechanical power. The skill of the hand is not inseparably connected with severe muscular exertion, although in many cases manual effort cannot be replaced acceptably by machinery. What can be done, and what is most effectively done by the use of compressed air, is to provide for the skilled hand such auxiliary power as will require only direction, and yet be at all times under perfect control.

Herein lies the demonstration, if demonstration be necessary, of the extent to which machinery which saves burdensome labour acts also to create further opportunities for skilled labour. When there is a greater demand for labour of a higher degree of skill, and when this demand is created by the introduction of apparatus which enables productiveness to be increased, we see that the ultimate effect of such appliances is to make more labour possible, while at the same time raising its character.

It is worthy of note that in operations in which mechanical power is substituted for manual effort the result is generally superior in quality to that formerly obtained solely by hand labour. This is doubtless due to several influences: the force at command is greater than could be exerted by the unaided hand, in addition to which the relief of the hand from the exertion of its full effort enables greater care to be given in guiding and regulating the mechanical power.

These Figures Are Typical Of The Savings You Can Realize With "CROWN" Sand Rammers

"Crown" Sand Rammers, Floor and Bench Types.

The table below shows the results of observations in representative foundries in different parts of the country. They are not "test" figures, but results accomplished under every-day working conditions.

Size of Cope	Time in Peining and Ramming By hand	By Sand Rammer	Ratio of Reduction	Per cent. time saved
12′x18″x4″	5 min	1 min.	1:5	80
12′x18″x10″	10 min.	1½ min.	1:6.6	85
6′x3′x6″	20 min.	3 min.	1:6.6	85
6′x6′x8″	35 min.	8 min.	1:4.4	77
8′x6″x6″	1 hour	10 min.	1:6	83
7′x3′x12″	1 hr. 30 min.	16 min.	1:5.6	82
15′x30″x16″	2 hours	27 min.	1:4.4	77
12′x7′x16″	2 hrs. 12 min.	34 min.	1:3.9	74
87″x159″x10″	4 hours	40 min.	1:6	83
19′x99″x15″	8 hours	1 hr. 30 min.	1:5.3	81

Note that these figures cover the entire job—both ramming and peining. **The saving of 74 to 85 per cent above indicated is fairly representative of what "Crown" Rammers will do for you, when they are intelligently used in average foundry work.**

And they give the further advantage of making better castings, more uniform and true to pattern, as a result of the harder, more uniform ramming. Write for Bulletin 8208.

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Local Steel Making

THE general idea conveyed by the manufacture of steel is that of a great works, with converters, open-hearth furnaces and quantities of machinery and men, all working at top speed under high pressure.

This, however, is only one point of view, and covers the operation of the production of steel in quantity, almost as a staple product, for railway, structural and manufacturing purposes. Under this idea the different kinds of steel are produced and delivered to the market as completed products, and the user selects the kind needed for his work, whether for rails, for building construction, tools, dies, machine parts, etc. A low-carbon, mild steel, practically incapable of hardening, is selected for boiler plate. Steel of somewhat higher carbon content is used for structural purposes, and so each variety is manufactured for its specific purpose.

When the material is needed for tools, dies and similar service in which definite temper or hardness is essential, the original product is positively specified, and engineers who desire to secure the best results in such work have been obliged, until recently, to purchase costly material and work it with difficulty in order to be sure of obtaining the grade of tool desired.

Methods of this sort will doubtless still continue to be followed for the manufacture of commercial products in quantity, but the development of the infusion process, enabling the carbon content of any piece of steel, or of any determinate portion of a piece of steel, to be increased at will, has made possible a reversal of the operation.

A piece of low-carbon, open-hearth steel of very moderate cost may readily be machined into any desired form. If it is a die to be cut, the annealed material is soft and easily manipulated by the tools of the die sinker, thus greatly reducing the time and cost of the operation. If it is some operative part of a machine, subjected to much wear, and thus requiring ultimately to be very hard, the forming of the piece may be effected while the steel is yet low in carbon and soft in character.

Then, by the local infusion of carbon, through the use of suitable sources of the element combined with proper heat treatment, the article may be practically made over, so far as its carbon content is concerned, not only as regards its entire mass, but with respect to local points which may demand special properties.

The extent to which carbon may thus be infused into a finished product is indicated by the fact that independent chemical tests have shown that such an article as a railroad spike, with an original carbon content of 0.11, showed, after infusion, that this had been raised to 1.78 per cent., permitting the highest practicable degree of hardening, according to the heat treatment subsequently applied.

One of the important things to be considered in connection with the infusion of elements into steel either generally or locally after machining is the possibility of introducing such an undesirable material as phosphorus, which, as is well known, carries with it the most objectionable properties of brittleness and weakness. The only way to be assured that no phosphorus gets into the steel during the infusion is to allow none to get near it.

The great point to be considered is that the matter of introducing the hardening element may be deferred until the operations of machining have been wholly completed, and that then the carbon and other alloying elements may be introduced just where desired and in just the proportions determined, while no injurious elements are used.

We thus have a process of local steel making which offers many advantages, and which is coming more and more into use.

You don't want Phosphorus in your steel, then why put it there by your case-hardening process?

See what Case-hardening Bone Contains

LABORATORY OF C. L. CONSTANT
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CERTIFICATE OF ASSAY

No. 42704 New York, March 23, 1912.

THE SAMPLE OF "Case Hardening Bone"
FROM Bought by us in open market for you
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Phosphoric Acid 27.16%
Equivalent to
Phosphorus 14.20%

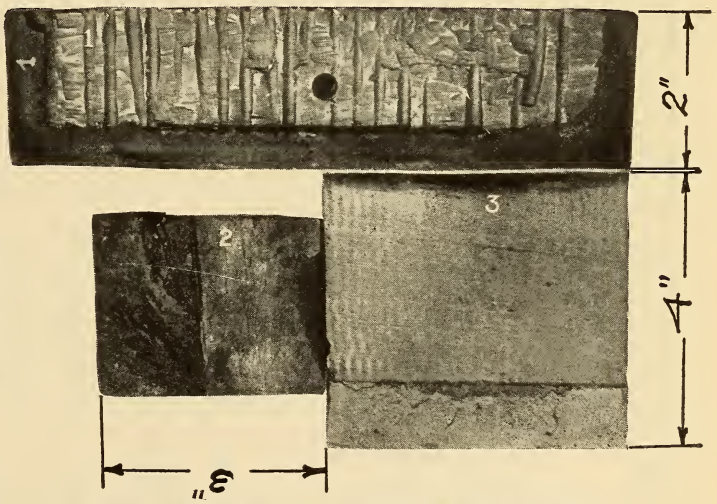
TO The American Infusion Steel Process Co.

Yours truly,
Signed by C. L. CONSTANT.

Better Use "STELPRO" For Hardening Steel

the scientific hardening mixture "STELPRO" contains no bone, therefore no Phosphorus, and produces better than Tool-Steel results.

"STELPRO" a suitable material



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Coal Output Doubles

Every 10 Years Production Equals Total of All Coal Previously Mined

An interesting, if not startling, fact in connection with the production of coal in the United States, according to the United States Geological Survey, is that in each successive decade the output is practically doubled. If the production of bituminous coal alone were considered, the record for the last fifty years would show an increase somewhat in excess of this ratio. The increase in the production of anthracite has been much less rapid on account of the limited area of the fields, the conditions under which the industry is carried on, and the restriction of the prepared sizes to domestic consumption. It has been estimated that the output of anthracite will reach 100,000,000 long tons annually before it begins to decline. An increase in the annual production of bituminous coal may be anticipated for some time to come.

The statistics of coal production in the past show that up to the close of 1865 the total output had amounted to 284,890,055 short tons. In the decade from 1866 to 1875, inclusive, the production amounted to 419,425,104 tons, making the total production up to the close of 1875, 704,315,159 tons. In the following decade, from 1876 to 1885, inclusive, the output amounted to 847,760,319 tons, somewhat more than double the total production during the preceding decade. At the close of 1885 the total production amounted to 1,552,075,478 tons, and the production during the ten years ended in 1895 was 1,586,098,641 tons, the total production at the close of 1895 amounting to 3,138,174,119 short tons. In the decade ended December 31, 1905, the total production amounted to 2,832,402,746 short tons, and the grand total from the beginning of recorded coal mining in the United States amounted to 5,970,576,865 short tons. The average annual production from 1896 to 1905 was 283,240,275 short tons; from 1906 to 1911, 461,499,260 tons, an increase of 63 per cent.

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TUNGSTEN AND ITS USES

AN UNUSUAL AND IMPORTANT MINERAL WIDELY EMPLOYED IN VARIOUS INDUSTRIES

Last year there was a sharp decrease in the production of tungsten ore, owing to the decrease in the demand for tool steels, in which the bulk of the tungsten produced is used, according to Frank L. Hess, in a report on this metal just issued by the United States Geological Survey. The production of domestic tungsten ore in 1911 amounted to 1,139 short tons of concentrates, carrying 60 per cent. of tungsten trioxide, valued at $407,985; in 1910 the production amounted to 1,821 short tons, valued at $832,992.

Tungsten is used chiefly in making steels that will hold their temper when heated, but it is most generally known as supplying the filament of tungsten incandescent lamps. The great improvements in drawing tungsten wire and further notable improvements in the size of the globe of the tungsten lamp and in other mechanical details that add greatly to its efficiency are making it encroach upon the carbon-filament lamp and the arc lamp, and it is rapidly driving from the market the tantalum lamp, which was the first good incandescent lamp having a metallic filament. Diamonds are used for dies in drawing tungsten wire. At first it did not seem possible to drill small enough holes through the diamonds to make wire sufficiently fine for lamps of small candle-power, but wire 0.0006 inch in diameter can now be drawn in quantity. The total quantity of tungsten ore used for electric lights, however, amounts to only a few tons a year. New uses of tungsten, in making electric furnaces, electric contacts, and targets for Roentgen rays, have been developed,

(Continued on page 71.)

PULMOTORS NOW INSTALLED AT TWENTY-THREE BYLLESBY PROPERTIES

The twelve additional pulmotors recently ordered for Byllesby properties are now being received. In every instance demonstrations by the companies have been followed by enthusiastic praise from the local press and physicians. In several cases medical societies have requested demonstrations at official meetings. This has been done at Mankato, Minn., and Grand Forks, N. D. Employees have shown an eagerness to be on the pulmotor corps. At Grand Forks, N. D., twelve employees of the Red River Power Company volunteered their services.

Quite recently a new use for the pulmotor was found. On Thursday, October 3, Miss Mattie Pierson, a patient at St. Anthony's Hospital, Louisville, Ky., was dying from the effects of a shock following an operation for appendicitis and the use of an anesthetic. The pulmotor of the Louisville Gas & Lighting Company was sent for. Dr. Wathen, one of Louisville's prominent physicians, who had charge of the case, wrote the company, saying: "I wish to thank your company for the prompt and efficient work done with your pulmotor. The patient is improving, and, we think, out of danger."

The value of the pulmotor has been proven amply in the saving of seven lives by Byllesby machines since their installation. Hardly a week passes but one or more of the machines are called into use. The first group of Byllesby properties to be equipped with pulmotors included the following: San Diego, Cal.; Mobile, Ala.; Muskogee, Okla.; Louisville, Ky.; St. Paul, Minn.; Eugene, Ore.; Fort Smith, Ark.; Pueblo, Col.; Stockton, Cal.; Tacoma, Wash., and Oklahoma City, Okla. The second group follows: Mankato, Minn.; Faribault, Minn.; El Reno, Okla.; Marshfield, Ore.; Stillwater, Minn.; Grand Forks, N. D.; Everett, Wash.; Sioux Falls, S. D.; Fargo, N. D.; Enid, Okla.; Eureka, Cal., and Minneapolis, Minn.

New Types of Frequency Meters

(Concluded from page 53.)

of the pointer are electro-magnetic, which results in permanent calibration.

The pointer is of U-shaped cross-section having considerable strength. Spring stops acting on the disk at each end of the swing prevent damage to the pointer, which might otherwise result from the sudden application of current at a frequency outside the range of the meter. In the round pattern meters the entire pointer is clearly visible, and any change from normal frequency, which is at the centre of the scale, can be noted quickly, even from a distance.

The bearings are mounted on a rigid casting secured to the meter case. The jewels are mounted in adjustable screws.

The cases of the round type meters match, in size and appearance, the 7-inch and 9-inch alternating-current and direct-current meters made by the Westinghouse Electric & Manufacturing Company, East Pittsburg, Pa. The line of 7-inch meters is particularly notable for its great saving in switchboard space. Vertical, edgewise and portable frequency meters operating on the same principle are also manufactured by this company.

Greatest Ocean Depth

A surveying ship of the German Navy has recently discovered the deepest known spot in the ocean. It is near the Philippines, about 40 sea miles off the north coast of Mindanao. Great depths were found to be numerous in this region, but the record sounding showed the amazing result of 9,780 meters, or 406 feet more than 6 miles.

The greatest ocean depth hitherto known was found by the United States cable steamer Nero in 1901. This spot was to the south of the Island of Guam, and the deep-sea lead indicated 9,635 metres—just a little less than 6 miles.

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OF THE
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SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

THE consensus of opinion among the leading business men of the country is that the United States is entering upon an era of prosperity which will equal that of any in its history.

A general awakening has taken place throughout the business world, and increased activity is perceptible in most lines of trade. The reports from farming communities give positive assurance that the wheat, corn and cotton crops will excel, both in quantity and quality. This same condition holds good in the fruit districts, and, in fact, there is scarcely an exception in the roll of success.

In a recent address before the American Iron and Steel Institute of Pittsburg Judge E. H. Gary stated that the activity which the iron and steel industries is enjoying at the present time will not be affected in the slightest by the Presidential election. Equally optimistic opinions are being voiced by leading merchants, railroad officials and manufacturers. Industries are showing large outputs with substantial profits, and the continued growth in car shortage is further evidence that our volume of business is decidedly on the increase. The underlying influences and conditions are of such eminently healthy character that we can hardly conceive of anyone seriously contemplating a panic in 1913. The only excuse for mentioning it is the fact that it happens to be the "Twenty-Year Cycle Period." And it would appear that some men who should know better have allowed themselves to temporarily fall under the superstitious belief that we are to again pass through the experiences of 1893. It must be remembered that we have learned many lessons since that time, and the past five years have been particularly rich in valuable experiences.

While our financial system is far from perfect and our tariff situation somewhat unsettled, yet it must be acknowledged that speculation is less rampant, and that there is a decided disposition on the part of the public at large to acquire wealth by more conservative methods. Investments are subjected to more careful scrutiny, and investors are influenced less by appeals from speculative brokers.

With our banking condition sound and the farmers promising unusual crops—manufacturers running overtime—there is every reason to be hopeful of the future.

The public have just begun to realize that the fear and uncertainty which have held them for the past few years was wholly unwarranted. There is nothing so contagious, and,

consequently, nothing so disturbing to the commercial world, as an aggravated sense of fear, which, if permitted to hold sway for any great length of time, results in panics and general business depression.

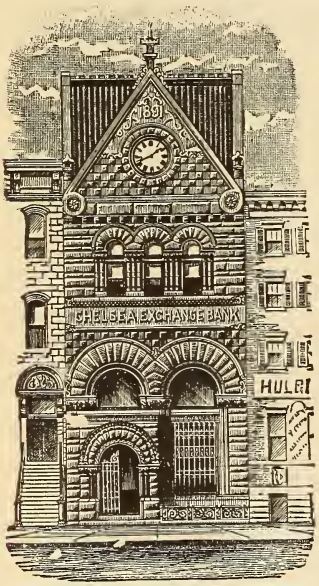
The first step, and perhaps the most important step, towards the restoration of commercial credits and confidence, is the elimination of fear and apprehension from the thought of those who are actively engaged in commercial pursuits. Just to the extent that we rise above a sense of limitation and throw off the shackles of doubt and uncertainty, just to that extent are we going to bring success into our own business, and, in so doing, contribute to the prosperity of the country as a whole.

We all influence more or less by our example, and for this reason men who are looked upon as being powers in finance, commerce and politics should measure carefully their words when discussing business and public affairs. Too frequently these men allow themselves to be influenced by partisan and selfish considerations, with the result that they either make or inspire others to make statements that are not founded upon fact and which tend to destroy the very thing most essential to success in conducting large business enterprises or administering the affairs of Government—namely, the people's confidence.

Question—What do you think of Erie Common as a purchase?

Answer—The Erie Railroad is today carrying a burden to the extent of ten millions of dollars for double-track improvements. It also has many other improvements under way, such as grades, yard track facilities, etc. When these improvements are completed the road will, naturally, be in much better condition physically, also from the standpoint of its earning power. We regard the stock as a good purchase for a long pull.

In the heart of the New Business Centre of the U.S.



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We have made rapid strides since our incorporation and our past history speaks for itself.

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Among other large orders recently received by the American Infusion Steel Process Company for their famous "Stelpro" steel hardening compound are the following progressive concerns:

Philadelphia & Reading Railway Company.
Braunsdorf Mueller Company.
E. W. Bliss & Co.
Southworth Machine Company.
American Locomotive Company.
Atlas Tack Company.
American Axle Company.
Denver City Tramway Company.
Standard Gauge Steel Company.

Question—Are preferred stocks issued against improved property in New York City considered reasonably safe investments?

Answer—There is no reason why securities of this kind under good management should not be one of the safest forms of investment on the market. There is no question as to the earning capacity of well-located, improved property in Greater New York; and as a further consideration in favour of such investments, the property, if well located, is constantly increasing in value.

Lockwood, Greene & Co., architects and engineers for industrial plants, have removed their Boston offices to 60 Federal street, where they occupy the seventh, eighth and ninth floors of the new First National Bank Building.

The New York Central has ordered 207 all-steel passenger cars for delivery next year. This is said to be the largest single order for all-steel passenger cars ever ordered.

TO INVESTORS! WE HAVE VALUABLE SECURITIES FOR SALE. Gilt edge real estate bonds, bearing interest at 6 per cent Payable semi-annually. First and second trust notes. BLANKENSHIP LAW & COMMERCIAL CO., Inc., Suites 525, 6 and 7 Colorado Building, Washington, D. C.

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A BARGAIN

As you are doubtless aware, the wireless question is settled by act of Congress, and the standing of amateurs is clearly set forth. There will be a great revival in wireless telegraphy this fall; and if you are interested in the subject, you will be glad to know what ELECTRICIAN & MECHANIC will do in this respect.

We have published in our October, 1912, issue, the complete text of the wireless law and the most valuable collection of wireless articles which has been contained in any number for the past year. Future numbers will have full information in regard to the regulations of the government for amateur stations, and instructions for complying with the law, as well as very strong articles on every phase of wireless operation. If you are interested, you will find ELECTRICIAN & MECHANIC an indispensable magazine of reference on wireless telegraphy.

This subject will by no means monopolize the contents of the magazine. Every one interested in electricity will find practical articles on other phases of the subject in each number. We aim to cover the whole field of actual electrical work; and the magazine is indispensable to any working electrician or student of electricity.

The other departments of woodworking, metal working and general mechanical work will receive their full share of attention, and the magazine will be the best rounded mechanical publication on the market.

If you have not been a subscriber of recent months, you have missed, in all probability, a large number of very valuable and useful articles. We have a few sets of the back numbers of this year. While they last we are willing to give all of the numbers for 1912, and the subscription for the complete year of 1913 for the regular yearly subscription price, $1.50. Canadian postage 35 cents extra for each year. Foreign postage 60 cents extra for each year.

Send us in your order at once and get the magazine for *twenty-four months* for the price of twelve. Do it *now* for the stock of back numbers is not inexhaustible.

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St. Paul Company Now Uses Water Power

The tie line between the main station of the Consumers Power Company, at St. Paul, and the Minneapolis General Electric Company's transmission line was completed Thursday, October 4. Connection has been made, and the Consumers Power Company, St. Paul, now receives current from the St. Croix hydro-electric station of the Minneapolis Company.

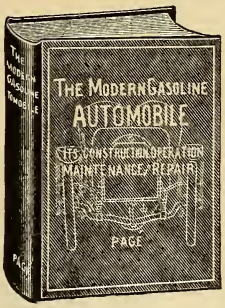
Minneapolis General Electric Company Secures Twenty-five-Year Franchise in Chicago

A 25-year franchise was secured from the city of Chisago, Minnesota September 30 for the distribution and sale of electricity. Chisago is a small suburb of Minneapolis

The United States Steel Corporation reports that its earnings for the quarter ending September 30, after deducting all expenses incident to operations and interest on bonds of the subsidiary companies, were $30,063,512. This was about in line with general expectations. The earnings were the largest reported since September 30, 1910, when they totaled $37,365,187, and compare with $29,552,725 for the September quarter a year ago. The increase reflects the continued improvement that has occurred in the steel trade since the preceding quarter, which, in turn, showed a gain over the first three months of the year.

The value of the brick, tile, terra cotta, pottery and various other clay products made in California in 1911, according to the United States Geological Survey, was $4,915,866. This is an increase of $73,475 over the figures for 1910.

In common with many other railroads, the report of the Chicago, Burlington & Quincy Railroad Company for the year ended June 30 last shows diminished earnings and higher operating expenses compared with the preceding year.



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Question—Do you advise the purchase of listed stocks in preference to unlisted stocks?

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It is doubtful if "Wall Street" will ever regain its influence in stimulating or depressing the country's business. The country is developing at such a rate that it cannot be controlled from any financial centre, however great. "Wall Street" may increase in power and influence, but not relatively at the same rate as the country at large.

Queston—Do you regard the copper metal market as offering good speculative opportunities at this time?

Answer—Undoubtedly the copper metal market is in an attractive condition at the present time, and the metal bids fair to experience a substantial advance. But it would appear to us that, unless you are in a position to keep thoroughly posted on the movements in the metal market, it would be a dangerous field in which to operate.

In the savings banks of the United States there are hundreds of millions of dollars which wage-earners have been able to accumulate through saving. These people cannot buy bonds of $1,000 denominations. A constantly increasing number of corporations are issuing $100 bonds.

Changes in the Officers and Board of Directors of the Joseph Dixon Crucible Company

At the regular monthly meeting of the Board of Directors of the Joseph Dixon Crucible Company, held Monday, October 21, the following changes in the officers and board of directors were made on account of the death of Vice-President William H. Corbin:

Mr. George E. Long, former treasurer, was elected vice-president, to succeed Mr. Corbin; Mr. J. H. Schermerhorn, former assistant secretary and assistant treasurer, was elected to membership in the board of directors and treasurer of the company; Mr. Albert Norris was elected to the office of assistant secretary and assistant treasurer.

The Debenture Corporation of New York, in a recent Market letter, make the claim that one of the most popular investments in Manhattan is the elevator apartment house. They say: "Like the loft building, its desirability is not limited by its revenue, but it is attractive to the investor as well, because of the almost certain increase in the value of the land."

The last of the big tobacco companies launched with the breaking up of the old trust has declared its initial dividend. Liggett & Meyers, which makes more cigarettes than any other company in the world, probably, will pay 12 per cent. per annum.

Tungsten and Its Uses

(Continued from page 62.)

and the last two products are being actively manufactured.

Even for purposes of war tungsten may have its uses, and investigations are now being made with a view to its application in the manufacture of projectiles.

The present small-arm service projectile is made of lead with a jacket of copper-nickel alloy. The principal advantage of lead over iron, which would, of course, be cheaper, is that

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it has a higher specific gravity. Because of this fact a lead bullet will have a smaller cross-section, and will, therefore, encounter less air resistance to its flight than will an iron bullet of the same weight, and it will, consequently, give a flatter trajectory and longer range. An iron bullet of the same diameter as the lead bullet could, of course, be made of the same weight by increasing its length; but this would at once necessitate giving it a higher rotational velocity to keep its axis tangential to its flight. To impart this added rotational velocity would call for the expenditure of energy, and so leave less for velocity of translation. With the exception of tungsten, lead is the densest metal which can be considered for this purpose, for gold is the cheapest of the other elements having a higher specific gravity than lead.

For military purposes the softness of lead is not an advantage, a soft-nosed bullet being tabooed in civilized warfare. For this reason and because of the fact that it is too weak to hold the rifling it has to be jacketed with copper-nickel alloy. To take the rifling and to act as a gas check, the tungsten bullet will require a copper band or its equivalent at the base.

The hardness and high tensile strength of wrought tungsten will give high penetrating power. The high melting point of tungsten will prevent the projectile from being harmfully upset at the base by the combined action of the high temperature and rapid impact due to the combustion of the powder charge.

The Next Great Step in Engineering Education

The University of Illinois is attempting to secure for its students in engineering the advantages of superior training for their life work, a training made necessary by the development of engineering.

Their method of approach is rather

(Concluded on page 78.)

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Oregon Society of Engineers.

Discussion of Papers, "Flood Protection for Mississippi Valley," at Meeting of July 8, 1912.
By GEORGE H. MAXWELL, WILLIAM von PHUL, CAPT. C. O. SHERRILL, GEORGE H. DAVIS, A. M. SHAW.
Louisiana Engineering Society.

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Full information concerning this system and data in regard to softening and purifying boiler feed-water may be obtained by addressing the Wm. B. Scaife & Sons Company, Pittsburg, Pa., whose several systems for water softening and purifying are so largely used.

American to Design Railway Dynamometer Car for Imperial Government Railways of Japan

Professor E. C. Schmidt, in charge of the Department of Railway Engineering of the University of Illinois, has been commissioned by the Japanese Government to design a railway

(Concluded on page 78.)

THE LATEST CATALOGUES

Freight and Package Handling Machinery

"Jeffrey Freight and Package Handling Machinery" is the title of Bulletin No. 74 just issued by the Jeffrey Manufacturing Company, Columbus, Ohio. This book contains 134 illustrations showing mechanical equipments that were designed especially for the economical handling of various materials, and includes their improved type of finger tray elevators for raising and lowering packages, barrels, boxes, sacks, etc. This work illustrates the diversified line of their products. As every equipment installed by them is designed to meet the particular needs of the work for which it is required, and as their engineering department has given much careful study to conveying problems and possesses great experience in successfully solving them, this book should be of the greatest interest to an exceedingly large number of persons.

For a copy of this new book, address the Jeffrey Manufacturing Company, Columbus, Ohio.

Chain Grate Stoker

A new catalogue has been issued by the Illinois Stoker Company, Alton, Ill., describing their type "A" chain grate stoker, which is designed to consume coal with the volatile matter running 30 per cent. or over, and their type "B" chain grate, designed to consume coal with the volatile matter running 30 per cent. or under, both machines burning the fuel for which they are designed successfully and smokelessly. The Illinois Stoker Company will send a copy of the catalogue on request to them, mentioning CASSIER'S MAGAZINE.

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Electric-Air Rock Drill

Form 4209, 16-page, 6 x 9 bulletin, issued by the Ingersoll-Rand Company, 11 Broadway, New York City, describes the Temple-Ingersoll electrictric-air rock drill manufactured by them. The "electric-air" drill is driven by pulsations of compressed air created by a pulsator actuated by a standard electric motor. The air is never exhausted, but is simply used over and over again, playing back and forth in a closed circuit. The drill is very simple—a cylinder containing a moving piston and rotation device, with no valves, chest, buffers, springs, side rods or pawls. The pulsator requires no intake or discharge valves or water-jackets. It is geared to a motor, either direct or alternating current, and mounted on a wheel truck for easy handling. Two short lengths of hose connect pulsator and drill, each hose acting alternately as supply and exhaust. The electric-air drill under ordinary conditions uses about one-fourth the horse-power required with the usual air or steam drill of the same work capacity. Catalogue is finely illustrated to show drill in section and at work.

Bulletin 4023 describes and illustrates the "4-E" type of electric-air rock drill manufactured by the Ingersoll-Rand Company, 11 Broadway, New York City. This machine will operate with either direct or alternating current, has a cylinder diameter of 4¾ inches, 7 inches stroke, and will drill a 1¼-inch to 2-inch diameter vertical hole up to 12 feet deep.

Bulletin 4025, Ingersoll-Rand Company, 11 Broadway, New York City, describes the "5-F" electric-air rock drill, which will drill holes 1¾ inches to 2¾ inches in diameter up to 20 feet deep; 5⅝-inch diameter cylinder, 8 inches stroke, uses octagon steel, and will drill a 30-inch hole without change of bit.

Catalogue 384-F, issued by the Ingersoll-Rand Company, 11 Broadway, New York City, gives instructions for installing and operating the Temple-Ingersoll electric-air rock drills, and Form 601 gives instructions for operating the "5-F" machine, together with list of duplicate parts.

Herringbone Gears

This pamphlet, issued by the Earle Gear & Machine Company, of Philadelphia, Pa., contains a discussion that will prove of interest. It recites the relative values of this type of gear, as compared with the ordinary spur gearing. It is claimed for the Herringbone gears that they will deliver power with minimum friction and noise. For a copy of this catalogue, address the Earle Gear & Machine Company, Philadelphia, Pa., and mention CASSIER'S MAGAZINE.

Lightning Arresters for Electric Railways

Bulletin No. 4960, recently issued by the General Electric Company, illustrates and describes direct-current lightning arresters for use in connection with electric railways. The arresters described are of two types: the magnetic blowout and the aluminum arrester. The type to be used depends upon the conditions to be met, and this point is discussed in the bulletin.

A copy can be obtained by addressing the General Electric Company, Schenectady, N. Y.

Plans for Concrete Houses

The Blaw Steel Construction Company, of Pittsburg, Pa., have issued an interesting book containing the plans for small houses of poured concrete which were submitted them in a competition for prizes which they recently held. Many of these plans are most attractive. A copy of this book can be obtained by addressing them at their general office, Westinghouse Building, Pittsburg, Pa., and mentioning CASSIER'S MAGAZINE.

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Dynamometer Car for Government Railways, Japan

(Concluded from page 74.)

dynamometer car for the Imperial Government Railways. The car will be constructed in this country under the supervision of Professor Schmidt, and is expected to be delivered next spring to the representative of the Japanese Government.

The car is to be 48 feet long, 8 feet 6 inches wide, adapted at present for 3-foot 6-inch gauge, with provision for changing later to 4-foot 8½-inch gauge. It is to be equipped with vacuum brakes, and the design of such details as drawbar, buffers, journal-boxes, etc., is to conform to Japanese railway standards. The car is to be of the hydraulic dynamometer type such as has been developed at the University of Illinois. The recording apparatus will permit the measurement of tractive efforts up to 80,000 pounds, and will provide also for the measurement of speed, time, distance, vibration, buffer thrust, etc. The car and the apparatus will be designed for a maximum speed of 85 miles per hour. Axle generator and storage battery will be provided to supply current for operating the recording apparatus and for lighting purposes.

The work has been undertaken at the instance of Mr. S. Matsuno, chief of the motive power section of the Central Division of the Japanese Imperial Government Railways, who has supplied the general specifications for the design. Financial matters are to be arranged in this country with Mitsui & Co., Ltd., of New York.

The Next Great Step in Engineering Education

(Concluded from page 73.)

different than that employed by other universities, and is clearly described in Bulletin No. 34, recently issued by them, a copy of which may be obtained by addressing Prof. W. F. M. Goss, Dean, College of Engineering, University of Illinois, Urbana, Ill., and mentioning this magazine.

PERSONALS

Mr. Wentworth P. Johnson has been appointed manager of the New York office of H. M. Billesby & Co., Trinity Building, effective October 1. Mr. Johnson for the last nine years has been the European financial agent of the International Harvester Company, residing in London. In this capacity he was highly successful, and having established satisfactory financial relations between European banks and the International Harvester Company, his services were available to Byllesby & Co. Mr. Johnson is an old friend and business associate of Mr. Byllesby, having been connected with Mr. Byllesby in the Northwest General Electric Company at St. Paul. Mr. Johnson was born at Norfolk, Va., in 1859. At the age of 26 years he went to St. Paul and entered the services of the Gordon-Ferguson hat and fur house, leaving that concern in 1891 to enter the services of the Northwest General Electric Company. After several years he became connected with the McCormick Harvesting Machine Company in the capacity of comptroller, and in 1904, after the formation of the International Harvester Company, went abroad to represent that concern, as described. Mr. Johnson returned from London only recently, and hereafter will make his residence in New York City.

The Pennsylvania Steel Company announce the appointment of Mr. J. Frank Haig as purchasing agent of the Pennsylvania Steel Company, the Maryland Steel Company, the Spanish-American Iron Company, the Penn Mary Coal Company and the Baltimore & Sparrows Point Railroad Company vice Mr. Stedman Bent, resigned. Mr. Haig's head-

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quarters will be at the company's offices, Morris Building, Philadelphia, Pa.

Frank Koester, consulting engineer, has removed his office from 115 Broadway to larger quarters, at 50 Church street (Hudson Terminal Building), New York. Mr. Koester is principally engaged in steam and hydro-electric power plant work, electric transmission and traction. He recently finished the plans for a central asphalt repairing plant of 3,000 square yards daily capacity, for which he was retained as an expert by the Borough of Manhattan, New York City.

President Maclaurin, of the Massachusetts Institute of Technology, announces that leave of absence till January 1 has been given to Professor Dugald C. Jackson, head of the Department of Electrical Engineering, who has gone to England at the British Government's request. A year and more ago, when the English Post Office Department considered the purchase of the different telephone lines, it determined to call upon one authority outside the country to work with the English Commission. The selection of the government was Professor Jackson, of Tech., who has been in consultation with the Englishmen two or three times and is now called to England for the final work of appraisal. The importance of the matter may be judged from the fact that not less than fifteen hundred exchanges are involved, with half a million subscribers, and the capitalization is not less than sixty million dollars.

It is a matter of a good deal of local pride at Tech. that the other out-of-England expert in the matter is Hammond V. Hayes, a Tech. graduate, '85, a Boston electrical engineer. Mr. Hayes is the expert who has been selected by the companies that are interested. Thus it is that the Institute of Technology presents the experts for both parties—an extraordinary evidence of the excellent reputation of the school abroad.

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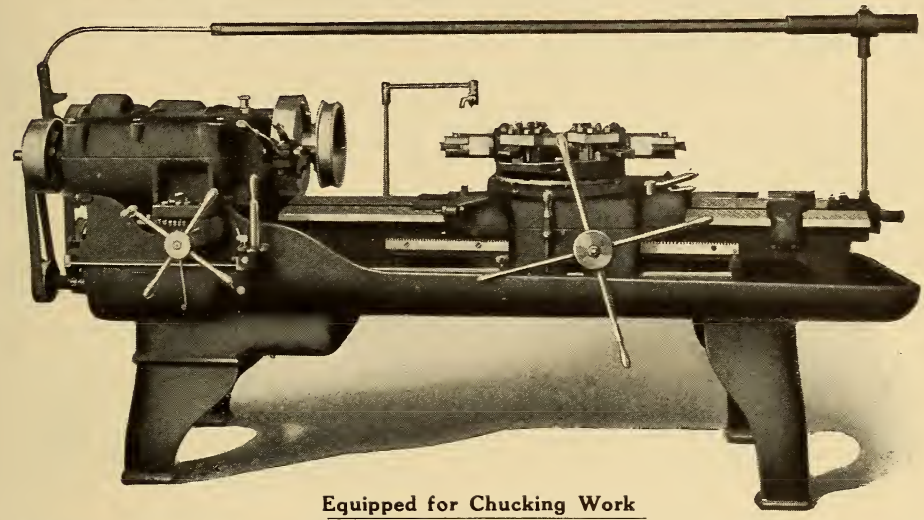

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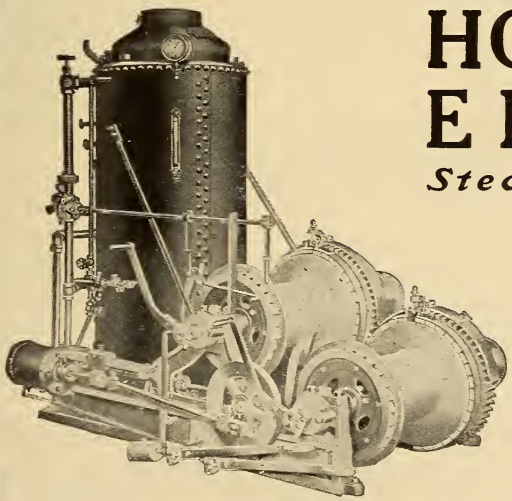

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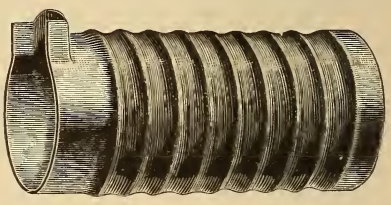

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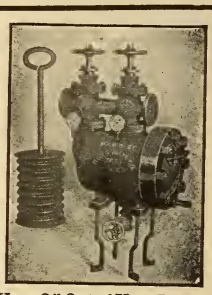

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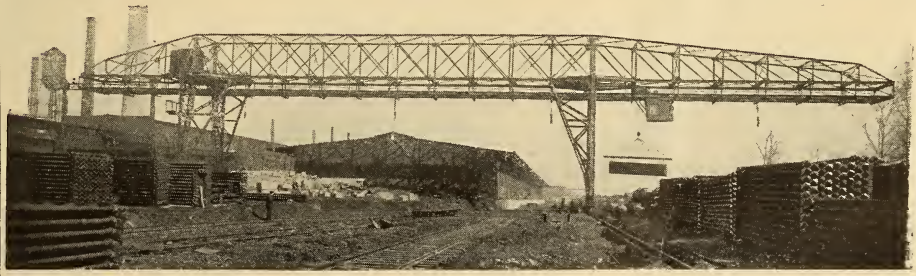

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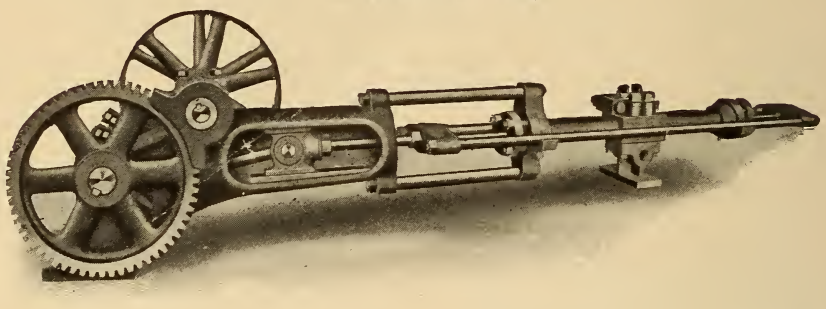

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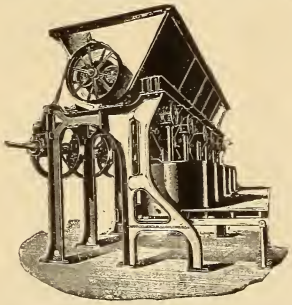

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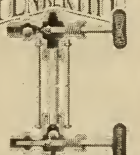

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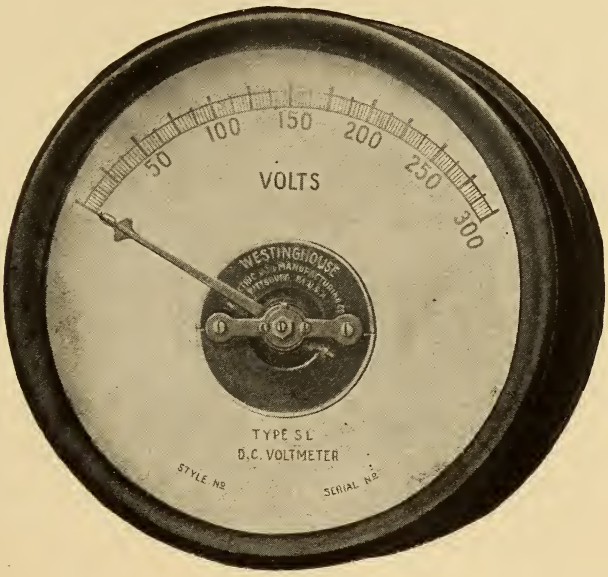

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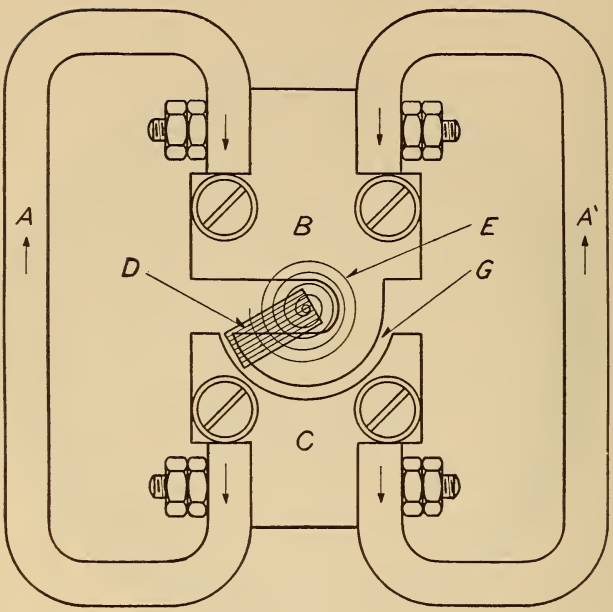
In the line of 5-inch, 7-inch and 9-inch direct-current meters recently brought out by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., a unique adaptation of this principle is used. The magnetic circuit, consisting of two permanent magnets with pole pieces, has only one airgap. The moving coil is pivoted at one side and the opposite side moves in this airgap. This construction, in addition to providing one airgap with large clearance, instead of two airgaps with small clearances, as is generally the case, also makes possible a better balancing of the pointer and results in a number of minor advantages.



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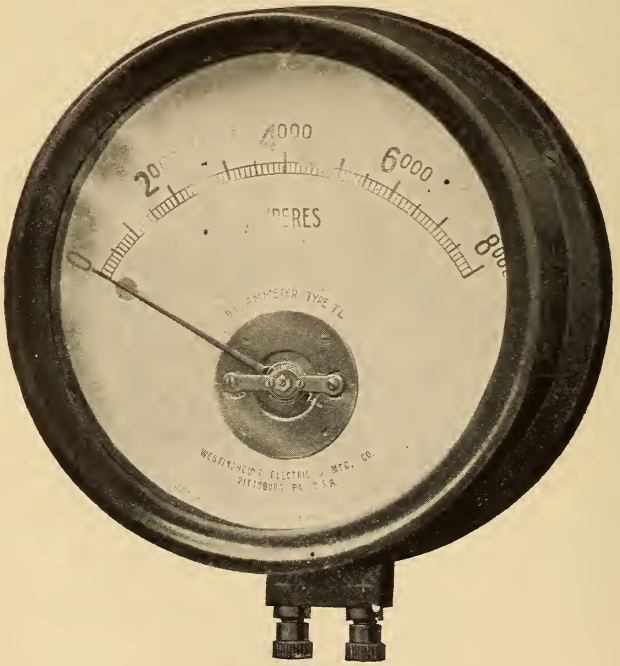

NINE-INCH D. C. VOLTMETER

D. C. SWITCHBOARD METERS

The illustration on facing page shows the general arrangements of the parts. The two permanent magnets *AA* are provided with soft iron pole pieces *BC*, each pole piece being common to both magnets. The moving coil *B* is wound and encloses the end of the pole piece *B*. This coil is so connected that current in it tends to move the coil away from the end of the pole piece with a force proportional to the product of the field of the permanent magnets and the magnetizing force of the coil. As the field of the permanent magnets in the Westinghouse meters is constant and uniform, the torque is exactly proportional to the magnetizing force of the coil—that is, the strength of the current in it. This torque is opposed by two spiral springs *E*, one located at the end of the pivot. As the restraining force of the spiral spring is proportional to the deflection, the deflection is proportional to the current in the moving coil. It is read by means of a pointer on a uniformly graduated scale. When used as an ammeter, the coil *D* is connected across an ammeter shunt through which passes the current to be measured, and when used as a voltmeter the coil *D* is connected, through adjusted resistance, across the voltage to be measured.

The complete magnetic circuit, including the pole pieces, is magnetized and aged as a unit, a process possible only with the single airgap construction, because the pole piece does not have to be removed to put the moving element in place. The parts of the magnetic circuit, therefore, are not changed in assembling the meter after ageing, so that the strength is not disturbed in any way. This insures a system more permanent than can be obtained by any construction that necessitates assembling the pole pieces or setting the airgap after the magnets have been aged, which is necessary with all forms of double airgap construction.

The permanent magnets are so arranged that they completely inclose the

MOVING ELEMENT, WESTINGHOUSE D. C. METERS

movement, effectively shielding the movement from external fields. The moving element consists of a suitable coil wound on a rectangular aluminum frame, a pointer, and a supporting frame work with steel pivots. The arrangement is such that the weight of the coil counterbalances the pointer as shown in illustration, thus reducing the amount of additional counter weight required and making the weight carried by the pivots a minimum. This condition is possible only with single airgap construction.

The controlling springs, which serve also to conduct the current to the moving element, are of a special alloy, formed and then aged, to insure permanence. Because of the high torque of the meters, a substantial control spring can be used. Its weight, however, is not supported by the moving element, but by the stationary pivot support, and the outermost convolution is adjustable attached to the moving element.

The pointer is an aluminum punching of channel cross-section and has considerable strength. It is clearly visible for its entire length in round type meters.

It will be seen that the weight of the moving element has been kept low by the arrangement and design of the parts and not by making any part delicate. The result is a moving element whose weight is well within the limits that experience has shown can

be carried safely on jewel bearings without danger of damage in shipment, and at the same time are substantial enough not to be structurally weak.

The scales of the meters are calibrated by hand, to give more uniform accuracy than is possible with printed dials. A feature of the meters is the method of attaching the scale dials. These are clamped at the center and free to expand and contract, so that there is no tendency whatever to buckle.

(Concluded on page 64.)

THE EFFICIENCY SOCIETY

The Efficiency Society, which was organized in New York City, March 18, 1912, and concerning which an article appeared in the April number of this magazine, has recently issued a handsome prospectus outlining its objects and purpose.

This society is the natural outgrowth of modern tendencies in all forms of business, industrial, professional and social life. Owing to the rapid development of civilization, with its multiplication and specialization of activities, the demand for capable leaders and executives has far exceeded the supply, and many men have had great supervisory responsibilities thrust upon them which they could not from the nature of their education or experience be capable of meeting. Some of these men, unaware of the fundamental principles of organization and management, have imposed upon their subordinates their self-devised methods, and when the latter did not meet with favor forced their adoption.

Compulsory methods always arouse resistance and resentment. This is evidenced in the unsatisfactory relationship which has developed between the employer and employee. For several years private firms and individuals have realized the necessity for improving this situation and thus increasing efficiency on the part of these two elements. They have been attempting to do this by what they have conceived to be a fairer treatment of the employee, and by standardizing operations, eliminating useless motions and preventing wastes.

Efforts also have been made by universities and local associations to educate executives in better methods of organization and management. Bureaus of municipal investigation have devoted no little scientific research and analytical thought to the efficiency question. Very recently popular attention has been focused upon it by important public utterances and discussions. Through these means has come a recognition of the validity of the sciences of organization and management, the former as important as the latter, although comparatively little is heard of it.

These sciences, however, are still to be properly formulated and correlated. The accomplishment of such a task demands a society of broad scope and inclusive purpose—a society of National extent. Only by a large body of individuals associated in this way can satisfactory progress be made in the development of the new sciences that are of so vital interest to every man in the world of affairs.

In the summer of 1911 the task of organizing such a society was begun by a few men in New York. The movement grew by accretion through nominations by its members, and late in the fall an organizing committee of 130 men was gathered. Among them were business executives from every field, public accountants and systematizers, industrial engineers, econo-

mists, educators, legislators and Government officials.

This committee formed the nucleus of the society. During the first two months of 1912 the plans of the society were definitely formulated. They were simple, but comprehensive. Briefly, they proposed that the Efficiency Society should provide a common meeting ground, where men who realized the value of efficient methods of accomplishment could become acquainted and exchange ideas. Such a society could not consider simultaneously every field of human enterprise, but it proposed to take up one field at a time.

The papers presented at the first meeting of this society and future ones are to be sent to each member, separately, in pamphlet form and at the end of the year in a complete volume which will include all the proceedings of the society.

The Efficiency Society has in hand a programme following up the work initiated at its first meeting, and intended to develop the sciences of organization and management in ways that will lead to efficiency in the industrial and other fields. This programme will be a dual one, in part curative of present inefficiency and in part preventive of inefficiency in the future. Simultaneously with this programme the actual situation will have to be carefully studied, and for this purpose a canvass will be made to find out the causes of inefficiency existing in each of a great many enterprises and to note the results of the efforts which have been made to correct it.

In the fall these data will be presented at a conference which will be attended by the deans of the colleges and universities throughout the country which have established courses in commercial and business administration, and an effort will be made there to harmonize and standardize these courses and to embody in them the proper information which will not only qualify the future employer for his work, but will also better equip men to do reorganizing and systematizing work in offices and factories and to modernize the methods of present employers. This conference will be addressed not only by men who have been successful in the various fields of human activity, but by the graduates of these schools, who will say whether the present curricula have been of value in their practical work, and suggest changes accordingly.

The society's headquarters are at present in the Engineering Societies' Building, 29 West 39th street, and will continue there until the growth of the society shall warrant its removal to its own building, a small nearby residence which has been offered to the society at a very reasonable rental, where its library and educational exhibit of photographs will be housed and meeting rooms will be provided for the needs of committees and small conference, thus supplying a place where members can drop in to obtain information, expecting to find others there who are interested in the same subjects and problems, and can exchange ideas. It will be open evenings and lodging will be provided for the convenience of out-of-town members.

At the time of its first meeting the membership numbered almost one thousand persons, drawn from practically every important social, professional and business interest and from every section of the country, and membership is growing continuously, united by the common purpose of securing and disseminating such information as will result in individual and general efficiency.

Mr. H. F. J. Porter, the secretary, who will be found during usual business hours at the present society headquarters, 29 West 39th street, will be glad to give full information regarding the society, its work and aims, and invites correspondence from all interested in this most important movement. Mr. Porter reports great interest in this new movement and the receipt of a very large number of inquiries and applications for membership.

Scientific Manufacturing

IN the older days of manufacturing it was apparently believed that the manufacturer had done his full duty when he produced something which met the market in a general way, and which was sold without any especial responsibility as to its fitness for the other things with which it was to be associated. The purchaser himself was supposed to know what he wanted and what he intended to do with it, and upon him the responsibility was generally allowed to rest.

Under the development of modern industry, however, a different condition obtains, and it is not uncommon for the customer now to obtain from the manufacturer a service which he could formerly not have obtained under any conditions. If a manufacturer desired to secure for any purpose an equipment which should be wholly complete and well designed, not only with regard to present but also future requirements, and which should include a scientific study of his methods and conditions, he had either to do this portion of the work himself or else employ a consulting engineer to whose plans and specifications the necessary material was supplied.

The modern method, adopted by some of the leading manufacturers of the country, is to supply with the goods which are sold such an expert engineering service as renders it wholly unnecessary for the customer to do more than indicate his general requirements, this service being the result of long experience and definite application of scientific methods to the use as well as the manufacture of the articles under consideration. Under such a system the purchaser receives something more than so many pounds of material and so much machine work, assembling and operation; he gets the result of years of experience of trained engineers and manufacturers put into the product, and in addition he obtains the benefit of the latest acquirement in expert engineering in the special line under consideration.

Such a method, with all that it implies, is a great advantage, not only to the customer, but to the manufacturer himself, since it enables him to be assured that the equipment which he furnishes will give satisfaction because it is adapted to the work to be done. Nothing can stand by itself alone, and every element in a mechanical equipment is largely dependent upon the other portions of the mechanism for its own efficiency.

When the surroundings and associated mechanism are supplied independently and without proper consideration of the character and construction of the elements with which they must act, there must necessarily appear a lack of co-ordination and consequent reduction in efficiency which can be avoided only by the use of some controlling head in the planning of the entire equipment. When, as is now frequently the case, such expert technical supervision is supplied by the manufacturers by whom the equipment is built, the customer is assured of a service wholly unattainable under the older conditions.

There is probably no department of engineering work in which such complete supervision is more essential than in the power transmission of a manufacturing establishment. Under older conditions it has been estimated that nearly one-half of the power generated in the engine room was absorbed in the course of the transmission to the productive machine tools. Apart from this direct loss, there were other losses due to defective arrangement of machinery, useless complications, and other elements of inefficiency whose magnitude could only be estimated. Much of the direct loss and nearly all of the indirect losses lay in details which, under modern expert service, are largely eliminated, so that the demand for efficiency is met by supplying both a scientifically planned equipment and a critical study of the especial case which that equipment is intended to meet. This is the true application of science to manufacturing, extended to meet the use of the product as well as its manufacture.

DODGE

Part of a Train Load of Dodge Heavy Rope Sheaves of Expert Design and Scientific Manufacture

Dodge Service Stops at Neither Size nor Weight

DODGE service, in designing and supplying Power Transmission Machinery, stops at neither *size nor weight*. "Everything for the mechanical transmission of power" is a simple, truthful description of its *scope*.

No jobs can come too big—none are too small—for the Dodge machine shops and foundries.

Whether your factory needs run to *extra heavy equipment* or to *ordinary sizes*, you should know the Dodge line. It should be your shop standard. It embraces the split feature and interchangeability wherever possible, and the splendid economy of self-oiling bearings.

Whatever your power transmission problem may be, you are invited to place it before the Dodge engineers—men of wide experience and mature judgment. They represent a sum total of practical knowledge of how to meet requirements and emergencies that will be of real value to you. Advise with them on any question of heavy engineering, power economics, distribution, or the standardization of parts. The service is entirely free of obligation.

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QUALITY D SERVICE

Pneumatic Tool Generalities

We have to take our mechanical inventions in the order in which they come to us, and we do not always get first the thing that is most wanted. The great opportunity for the use of compressed air as a relief and helper in the most exacting details of manual labor in the shops was long ago recognized, though perhaps few realized at first how much it would be able to do for us.

The most tedious and fatiguing of the workman's tasks have been eliminated, and at the same time his output has been increased and improved, but neither he nor his employer has had much choice as to the tools that should be first provided and has had to take them in the order in which they have happened to come.

In the getting up of air-operated tools for the shop, or for portable use anywhere, why should the percussive tools have so long preceded the rotative tools, when the latter form so large a portion of the tools normally employed? If any regard was had to actual practice, and to the demand which might have been predicated from it, the percussive tools and the rotative tools should have been started out together or, if anything, with the latter somewhat ahead. Not only is there a great demand for handy rotative power for drills, taps, reamers, for grinding; in valves, for tube beading, for wood augers, for emery wheels when carried to the work, etc., but the number of these operations is continually increasing, while chipping and work of that character tend rather to decrease.

Well, the rotating drill, or drill driver, has arrived and, as usual, it has not come by the most direct route. There is perhaps nothing more common, and at the same time more curious, than our persistent placing of the cart before the horse in the process of developing our mechanical and other inventions. The more obvious arrangement of the horse before the cart is generally the last to be arrived at, and simplification taxes ingenuity more than complication does. The most perfect and effective contrivances we produce are ultimately the simplest, but the simplicity is only attained after complication upon complication has first been devised and adopted and then been tediously eliminated by the exercise of much patient effort.

We like to make a fuss in our doings, whatever they may be, and mechanical fuss or complication has its attractions for us. Some things seem to get a start in popular estimation from the beginning just from the imposing array of details they present. The very size and the full war panoply of Goliath assured him of victory in advance, but the smooth stone from the brook and the shepherd's sling scored the knockout.

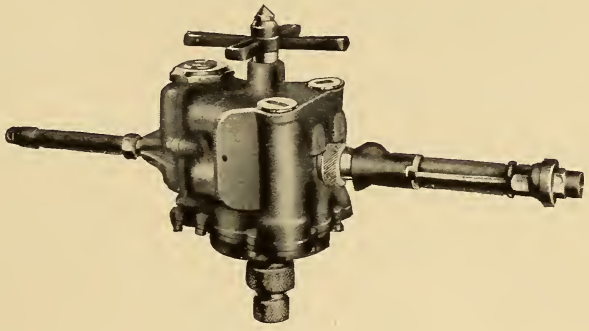
The rotative drill, as now simplified nearly to perfection, makes very complete the pneumatic kit of the metal worker especially, so that it is now difficult for the inventor to find any more wants to fill in that direction. What more, for instance, can be done for the boiler maker? Only a quarter of a century ago his trade was one consisting of hand operations almost entirely, and now there is scarcely any hand manipulation—if we are permitted the tautology—left for him, while his former wonderful manual dexterity in riveting is becoming one of the lost arts, lost for want of exercise on the one side and for the lack of any market for such skill on the other.

With air hoists and jacks to begin with, the complete line of pneumatic hammers, riveters, chippers, caulkers, and then the rotative tools for the other operations, the trade once so dependent upon manual skill is now most independent of it.

Perhaps nothing so wonderful and complete in trade transformation as this, or accomplished in so short a time, can be found in history, and the effective agents have been the series of devices comprised between the air compressor and the little rotative drill.

Let Us Tell You The Story Of

"Little David"



It isn't a long story—but it's too long to tell here. And it is **very** interesting to every shop manager and superintendent and foreman who has use for a pneumatic drill.

The "Little David" is a **new** drill—**new** in every respect—**new** in design—**new** in the standard of workmanship and materials it represents—**absolutely new in the way it works and keeps on working.**

Here are three things for you to consider, while you're waiting for the complete story of "Little David."

The "Little David" will do more work per unit of power than any other drill built.

The "Little David" has only two-thirds as many parts as any other drill for similar duty.

The "Little David" requires less attention and costs less for repairs than any other drill.

The explanation—and confirmation—will be found in Bulletin 8007, which we are waiting to send you. It tells the story of "Little David."

NEW YORK **INGERSOLL-RAND CO.** LONDON

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OMPRESSORS ROCK DRILLS ELECTRIC-AIR DRILLS

CORE DRILLS PUMPS PLUG DRILLS PNEUMATIC TOOLS

No. 12 PT.

Infusing Efficiency

IT is an interesting fact that in most industrial operations the indirect methods are those which occur first to the mind of the engineer, and such methods often acquire such a firm hold that it is with difficulty that they are replaced with other and simpler plans. Thus, in nearly all construction work, the materials to be used are usually considered first with respect to their final service, and the strength, stiffness, hardness and permanent properties of materials of construction are given important place in design. These properties are taught as an important department of the science of machine construction; and very properly, since it is upon such qualities, as determined by scientific testing and by experience in actual service, that the value of the completed work depends.

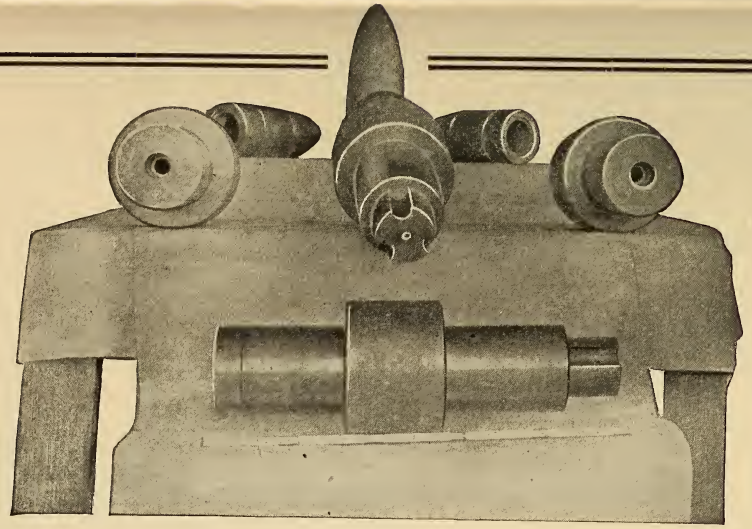
It is curious, however, that in nearly all text books and treatises upon materials of construction, the suitability of materials for the operations which are involved in manufacture is given scant consideration. The material must be strong, tough, often it is required to be very hard, and frequently such properties are desired to be combined, but little or nothing is said about the manner in which it is to be cut or otherwise finished in the course of manufacture. As a natural consequence the machinist is required to cope with all sorts of materials, and to do his work under disadvantages, many of which might be avoided or diminished if this portion of the subject had been given better consideration.

At the present time, however, this matter is being taken up in a more intelligent fashion, and this is largely due to the developments which have taken place in the treatment of materials, and especially with the demonstration of the possibility of imparting hardness after machining to steel which in its original condition is soft and readily machined. The development of the infusion process by which, in connection with proper heat treatment, the carbon content and entrance of special alloys may be effected after the operations of machining are completed, is working a transformation in workshop operations and permitting a material such as steel to be soft and readily workable until finished, and then given just the required degree of hardness at the especial points where hardness is essential.

It is this control, not only of the degree, but also of the location of hardness, which forms one of the valuable characteristics of the infusion process. Extreme hardness is a very valuable property for certain purposes, and such an object as a roll for working metals must be hard in order to effect the extension and compression of the material upon which it has to work. Hardness, however, considered by itself, includes a certain degree of brittleness, and experience has shown that, apart from the difficulty and cost of turning hardened rolls, there is a frequent occurrence of breakages which is both costly and annoying.

Since the hardness of a roll is required only at and near the surface, it is evident that the infusion process gives opportunity for providing the combination of toughness and hardness which is the best preventive of breakages, while at the same time permitting the machining to be done upon the tough and soft material before the hardening operation is effected. The problem is not unlike that of armor plate, in that it requires two almost opposite properties in different parts of the same piece, and the solution has been found in practically the same manner, by performing the hardening at the latter stage of the work and upon the desired portions only.

It is interesting to note that the method of testing for hardness by the well-known Brinell method, noting the depth to which a hardened steel ball is impressed into the test specimen, involves practically the same requirements demanded of a well made roll, so that a roll hardened by the infusion process becomes its own test as soon as it is put into service.



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"Stelpro" can be used over and over again

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Class "B" for all Wearing Surfaces

DO NOT ACCEPT OUR STATEMENT

We desire the opinion of the other fellow to convince you that both efficient service is gained and money saved by use of "Stelpro," Class "A" for cutting tools, Class "B" for wearing surfaces.

Write for Letters from "Stelpro" users, illustrated booklet and full information

American Infusion Steel Process Co., 60 Broadway, New York

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YOU can burn less fuel, swallow less medicine, wear less heavy clothing and save money easier in Texas than elsewhere in the world. You can plant something and harvest something three hundred and sixty-five days in the year. You can raise practically everything raised in every State in our country, and in every country on earth. You can raise three and four crops of vegetables in succession—on the same ground—in the same year.

Our Booklet, Sent Free, Tells The Story

Insure Your Future Against Want

MOST men have a longing to become millionaires. It seems to be a popular idea that happiness and contentment can be associated only with unlimited wealth. There is no doubt we should be considered benefactors of our race if we could tell our fellow mortals how to become wealthy. We make no such claim and have no such power.

The man or woman who would possess a fair supply of this world's goods, must first learn to spend less than they earn, then learn how to put their saved dollars to work for them. No man ever got rich by the 3% route. It is also well understood that no one gets rich by hoarding money.

A few men have gone to bed poor at night and were rich when they got up in the morning. These cases, however, are few and far between. There is no quick and easy way of getting rich.

Courage and energy count. The more intelligence a man has, the greater his earning capacity. The laborer plowing a field works harder and longer than does the ranch superintendent, who receives ten times, or possibly one hundred times more salary.

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the land of realization for the man of limited capital

The Land of Promise

that fulfils its promises

Nine Weeks' Growth of Corn

12,000 Acres in a Three Crop Country

THIS Company owns over 12,000 acres of land in Hidalgo County, known as La Jara Farms, in the Rio Grande Valley of Texas. The project has so many remarkable features that it is impossible to cover them all.

The Rio Grande Valley Company
334 FIFTH AVENUE
New York

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WE will deliver to you a forty-acre farm within easy distance of railroad, churches, schools and business houses—all good, productive, level land—providing you pay 10% down and a few dollars a month.

When payments are completed you receive a deed to the forty acres, which should produce an income of from $2,000 to $20,000 a year. $20,000 is equal to 5% interest on $400,000. Prices are subject to advance without notice.

If you cannot go to Texas to select your own farm we will allot you a plot best suited to your wishes. You may have three months in which to personally inspect your farm, or make investigation. If, for any reason, you are dissatisfied we will exchange your farm for any other unsold tract.

Any time you choose to complete your payments a discount will be allowed from the amount still due. You are not spending money when you invest it in fertile land like this—you are merely changing the location of your funds—and in its new location it should yield larger returns.

A Profitable Field of Cotton

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Rio Grande Valley, Texas

A Valley Located
Where frost is not to be feared
Where three or four crops a year
may be raised on the same land

A Land of Opportunity

for even the inexperienced

The Rio Grande Valley Company
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New York

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IT is a plain circular, a plain statement of facts told in a plain way, telling a true story, which will appeal directly to you and will show you how a few dollars securely invested in a Rio Grande Valley Farm will net an assured income of from $2,000 to $20,000 each year.

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Industrial Press Co.

KANSAS CITY, MO.

D. C. Switchboard Meters

(Concluded from page 54.)

The meters are furnished as voltmeters and ammeters, in six types: 5-inch, 7-inch and 9-inch round types, also illuminated dial, vertical edgewise, and portable types. The 7-inch round type, because of the length of its scale and flat glass front, marks a distinct advance in meter design. It will be noted that it can be enclosed in a rectangle of less than 55 square inches, so that it occupies practically as little switchboard space as the smallest "edgewise" meters on the market. At the same time its scale is seven inches long—as long as the scales on most nine-inch meters, making the indications clearly readable. The flat glass front, exposing the entire pointer to view, adds to the readability and makes it possible to avoid the troublesome reflections encountered in the use of meters with curved scale.

Testing Building Materials

A function of the testing station maintained by the National Fireproofing Company, which is found to be of great value to architects, engineers and contractors, is the testing of materials made by other concerns. Stone, concrete, brick and other materials entering into the construction of a building can be tested there in the presence of the architect, engineer or contractor—this service being undertaken by the National Fireproofing Company for the good of the profession.

To an architect or engineer this testing station of the National Fireproofing Company is a great convenience, as it enables him to see by the results obtained just what the materials he intends to use will do under certain loads, thus making it unnecessary for him to take the claims of any manufacturer without verifying the statements himself. By addressing the National Fireproofing Company, Pittsburgh, Pa., full information may be obtained concerning this department.

Lectures on the Smoke Problem

In the fall of 1911 the Department of Industrial Research of the University of Pittsburgh was provided by a Pittsburgh business man with funds for a thorough investigation of the smoke nuisance. At the present time the investigation is being conducted by a staff of twenty-five specialists, of whom seven are giving their entire attention to this task. Some of these men are studying the effect of smoke and soot on the atmosphere, on the weather, on plant life, on buildings, on the public health; some are investigating the economic damage done by smoke and soot; others are making a detailed study of the mechanical devices for preventing or abating smoke; and still others are inquiring into the chemistry and physics of smoke and soot, into the laws concerning the smoke nuisance, and into the history of the subject as a whole.

Recognizing the interest in the smoke problem manifested by a large number of American cities, and in response to inquiries that have been made, the department announces that the members of its staff are prepared to lecture on the following phases of this problem:

1. The Smoke Nuisance (a general presentation of the main phases of the subject).
2. Smoke and the Public Health.
3. Smoke and the Cost of Living.
4. Smoke and Plant Life.
5. Methods and Means of Smoke Abatement.
6. The Effect of Smoke on Buildings and Building Materials.
7. The Psychology of Smoke.
8. The Smoke Nuisance and the Housekeeper.

For further particulars apply to Dr. R. C. Benner, Department of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

Ford, Bacon & Davis, engineers, 115 Broadway, New York, announce that on July 1 last Mr. Charles F. Uebelacker, Mr. Charles N. Black and Mr. William von Phul were admitted to partnership.

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Constructor

A Handbook of Machine Design

By F. REULEAUX

Authorized Translation from the Latest German Edition
BY
HENRY HARRISON SUPLEE

SINCE the first presentation in the English language of this monumental work, it has found its way into a large proportion of the engineering offices and machine works of the United States and Great Britain, and to-day it is recognized everywhere as the **Standard Treatise on Machine Design.**

Its influence upon the design and proportions of machines of all kinds has become as powerful in America as it had already been in Europe, so effective has been the presentation of correct theory and sound practice in its pages.

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THE professional man and the business man have the necessary educational equipment and the practical experience to understand the conditions governing the judicious investment of money.

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Information on industrial and other securities of value to investors and men of affairs.

OF THE

INDUSTRIAL WORLD

SUBSCRIBERS AND READERS of this Magazine have the privilege of securing an expression of opinion on any investment or financial matter. There is no charge for this service, as it is the desire of this Magazine to serve in every way possible the best interests of its patrons. All inquiries are to be addressed to the Financial Editor.

CHARLES EASTON, Financial Editor.

The Situation

THE past month has been decidedly a waiting period in the business world, and though wholly unwarranted, timidity has served as the dominant characteristic.

The crop reports thus for received, have been splendid, and it is conceded upon all sides that there is little or no excuse for further delay in commercial activities. Banks are well fortified against any chance of monetary stringency, and most of them have more substantial reserves than is usual at this season of the year.

Good reports are heard from the steel trade and the copper metal market continues to give eidence of enduring stability. The securities market, however, has been narrow, dull and uncertain. It is only reasonable to suppose that the large banking houses are not going to encourage an upward movement in stocks before they have disposed of a substantial amount of the bonds they are now carrying. In our judgment, the underwriters of these low rate bonds will be unable to find a ready market unless they offer them at more attractive prices. The investing public generally is demanding a better return on their money and are showing a disposition to accept better grade preferred shares and unlisted securities yielding 6 per cent. or better, rather than to buy listed bonds with the lower rate of income. We have had an occasion to investigate several issues of unlisted securities that pay better than 6 per cent., and in almost every instance we have found the collateral behind same to be sound.

It is notable that the investor is manifesting a desire to decide for himself the best method of employing his surplus funds and is being guided less by the recommendations of local bankers, whose advice is apt to be governed by selfish motives.

When considered from the standpoint of basic conditions, there is no logical reason for the present sluggish situation in the stock market, because never in the history of this country have we had a better foundation upon which to build business prosperity than we have to-day. In view of this fact, it is most regrettable that able business men fail to show an inclination to rise above the discordant elements incident to a political campaign, and are allowing their prejudice against certain principles advocated by men prominent in the political arena to lead them into such a radically reactionary position that they not only cease to be a means but actually be-

come a menace to legitimate business expansion.

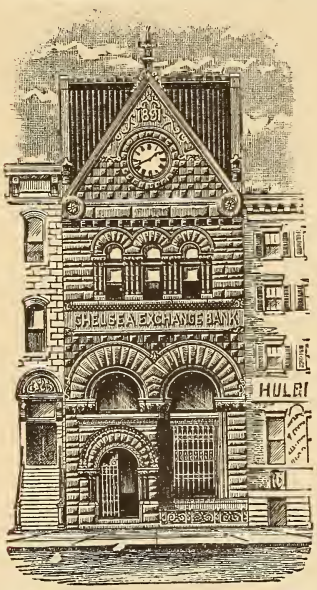
We cannot conceive of a greater blunder or a more stubborn hindrance to the restoration of normal prosperity than for the leading financiers of this country to treat lightly the new political factors that have arisen and endeavor to dismiss them contemptuously as an outgrowth of sordid ambition, or the product of a disordered mind. Far better would it be for all if the men to whom we look for the management of great enterprises would employ the same discretion, levelheadedness and foresightedness in dealing with new political proposals that they would in considering plans for the future development and safety of great railway or commencial enterprises, in which connection many of them have shown an almost prophetic vision as to the possible needs of this country.

Question—Do you regard this as an opportune time to buy railroad securities?

Answer — Generally speaking, we believe that the railroad list of securities offers many unusual advantages at this time. It is of course necessary to exercise due caution and judgment in selecting the issues.

W. R. Grace & Co., ship owners, of 1 Hanover Square, who operate a line of steamships through the Straits of Magellan to the west coast of South America, have placed orders with William Cramp & Sons of Philadelphia for two steamships to trade between New York and the Pacific Coast via the Panama Canal. They are to be about 405 feet long and not to exceed $1,500,000 each in cost. The boilers are to burn either coal or oil.

In the heart of the New Business Centre of the U.S.



Chelsea Exchange Bank

OUR NEARNESS to the Pennsylvania Station and the new Post Office, which is being rapidly completed, makes it convenient for the transaction of business.

We are always in a position to take on new business and advise those contemplating a change in their banking connection to pay us a visit, and we will be glad to go over financial affairs and make arrangements for the transaction of business.

We have made rapid strides since our incorporation and our past history speaks for itself.

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A Continually Growing Bank in a Continually Growing District

On July 1, last, the Brownell Company, of Dayton, Ohio, manufacturers of high-grade engines, boilers, feed water heaters, tanks, etc., opened a district office at 1418 Oliver Building, Pittsburgh, Pa., in charge of Mr. B. S. Rederer.

The Union Iron Works, of San Francisco, Cal., was awarded by the Mexican Government the contract for the new Pacific coast lighthouse tender.

It is understood that this vessel will have a rapid-fire, semi-automatic, six-pounder gun on her forward deck, which will give her many advantages as a coast cruiser.

This follows the example of both Chile and Argentina, Chile having awarded its immense contract for seacoast fortifications to the Bethlehem Steel Co., of Pennsylvania. The Argentine contract for naval armament was $33,000,000 gold. Mr. Archibald Johnston conducted the operations for the Bethlehem Steel Co. Both of these markets have for many years been dominated by European manufacturers.

Freight Rates to South America.....

None of the steamship companies operating between United States ports and the west coast of South America provide the importers of this country with a classified schedule of their freight charges, such as is furnished by the carriers from European ports.

The lack of such a schedule is felt keenly by all firms doing a direct import business with the United States, even though they may have their buyers in New York, as it is often desirable to quote customers from a new catalogue and on short notice. It is highly important, therefore, that American manufacturers seeking business on the coast of South America include as much as possible of this data in their catalogues and other propaganda literature. They should have their line classified and obtain freight rates on the same to this coast. They should also give some idea as to the freight from the factory to the port of shipment when they quote prices on board train at the former place.

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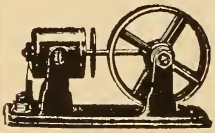
The magazine to read if you want to keep up to date on wireless and progress in electricity. With one year's subscription to Modern Electrics for a limited time only we are making the following:—



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Question—What do you think of speculative syndicates, formed for the purpose of operating in Wall Street securities?

Answer—By all means turn a deaf ear to such propositions. Usually those who are offering to sell their advice on the money-making methods of Wall Street, are men who have gone broke trying to make money for themselves by following some petty system.

It is confidently expected in the pig iron circles that prices will reach a much higher level within the next thirty days. The Steel Corporation has allowed the Independents to take the initiative in the advancement of prices in all classes of steel. Most encouraging news continues to come from the iron and steel trade.

Sales of Multistage Centrifugal Air Compressors

Within a short period the General Electric Company has received the following orders for multistage centrifugal air compressors for service as blast furnace blowers:

One 25,000 cubic feet per minute, 15 to 25 pounds pressure compressor, driven by a high-pressure steam turbine from the E. & G. Brooks Co., Bridsborough, Pa.

One 13,000 cubic feet per minute, 16 to 25 pounds pressure compressor, driven by a mixed pressure turbine, Chattanooga Coal & Iron Co., Chattanooga, Tenn.

Three 40,000 cubic feet per minute, 15 to 30 pounds pressure compressors, driven by high-pressure steam turbines, Woodward Iron Co., Woodward, Ala.

The General Electric Company has six multistage air compressors already installed as blast furnace blowers.

The principal advantage of this type of compressor are great saving of floor space, great saving in net weight, large saving in oil supplies and maintenance, and excellent control of re-

quired volume and air against whatever pressure may be required in the operation of the blast furnace. This close control of air is accomplished by a constant volume governor, which is one of the unique features of these blowing engines.

The recent report of the Brooklyn Rapid Transit shows earnings of better than 8 per cent. on its total capital of $45,000,000. This remarkable showing is indeed a tribute to present management of a company which ten years ago showed earnings of less than a half of one per cent. on the same capital.

July was a banner dividend month. The stockholders of 192 corporations received a total of nearly $49,000,000.

It is interesting to note that New York City has 107,000 employees and a payroll of nearly $100,000,000 annually. The city also has 770,000 enrolled school children and it requires 21,626 teachers to look after them.

In a recent real estate market letter the Debenture Corporation of New York, 334 Fifth Avenue, states that the total valuation of all New York City property, both taxable and exempt, is $8,775,851,638, which is greater than the assessed valuation of Pennsylvania and Massachusetts combined. In the same letter the Corporation states that the real estate securities market is reasonably active and a constantly growing demand is being manifested for good real estate securities issues against well selected properties.

The following is from a speech in 1833 by Daniel Webster in the United States Senate: "There are persons who constantly clamor. They complain of oppression, speculation, and pernicious influence of accumulated wealth. They cry out loudly against all banks and corporations, and all means by which small capitalists become united in order to produce important and beneficial results. They carry on mad hostility against all established institutions. They would choke the fountain of industry and dry all streams. In a country of unbounded liberty they clamor against oppression. In a country of perfect equality they would move heaven and earth against privilege and monopoly. In a country where property is more evenly divided than anywhere else they rend the air shouting agrarian doctrines. In a country where wages of labour are high beyond parallel they would teach the labourer he is but an oppressed slave." While Webster is passed and gone, such thoughts as the above will live forever, and could be profitably studied by present-day statesmen.

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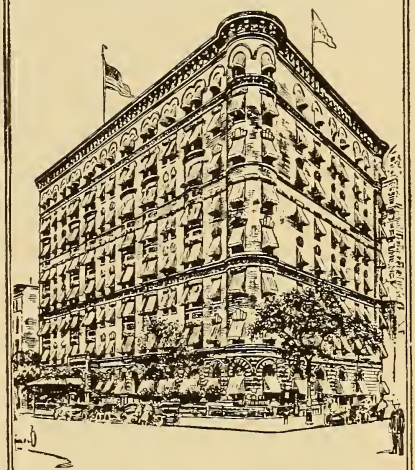

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Painting the Smokestack

The service demanded from smokestack paint is in some respects very severe—the two most destructive elements usually encountered being the excessive heat and the sulphurous gases that escape from the stack, and engineers are often at a loss to know which paint is the best to use, so that long service and protective efficiency will be assured.

A little book, under the title of of "Painting the Smokestack," just issued by the Joseph Dixon Crucible Company, Jersey City, N. J., will be found to contain many valuable hints on this subject.

The most economical paint is the one that will put off repainting for the longest period while protecting the stack from deterioration, as the big item in any painting job is the labor, which costs about the same, regardless of the quality of the paint and its protective efficiency. In the case of stack painting the cost is increased because of the hazard, since painters are in danger of serious burns or fatal falls.

A copy of this book will be sent free on request by the Joseph Dixon Crucible Company.

Air Cushions for Automobiles

The air-cushion automobile invented by Josef Hofmann, the pianist, and constructed at the Saurer Machine Works in the consular district of St. Gall, Switzerland, promises to bring about a revolution in automobile construction. In place of the usual steel springs it has four brass cylinders for compressed air resting on the axles under the four corners of the automobile body, and these, by means of pistons and soft leather diaphragms, greatly reduce the swaying and jolting.

It is claimed for the new invention that it is adaptable to all kinds of roads, regardless of speed or weight of machine; that the air cushions work instantaneously with softness and ease of movement; that there is an entire absence of vibration, as no metal springs intervene between the axle

(Concluded on page 73.)

Brueau of Manufactures Publishes Bulletin on the Utilization of Atmospheric Nitrogen

The importance of nitrogenous compounds to the agricultural and industrial interests of Europe and America has prompted the Bureau of Manufactures to issue a monograph on the subject of utilizing atmospheric nitrogen in the production of such compounds.

The nitrogen problem, one of the most pressing of the twentieth century, is unique from the fact that the material is unlimited. The atmospheric nitrogen above one square mile of land, amounting to about 22,000,000 tons, is equivalent to what the world would require in the next fifty years at the present rate of consumption. The problem is to utilize this nitrogen economically, and thus free the world from its dependence on the nitrate deposits of Chile, which are not particularly extensive and are likely to be exhausted at a comparatively early date.

Remarkable results have been obtained in Norway by means of electric furnaces, in which atmospheric nitrogen is oxidized to the form of nitric oxide, which is used in making calcium nitrate, or Norway saltpeter. This Norwegian product is already an important rival of Chile saltpeter; but as the success of the process depends upon a very cheap supply of electricity, it will probably not be used to any great extent in the United States until the furnaces have been made more efficient.

Cyanamide, another nitrogenous fertilizer of growing importance, is being manufactured in America and the industry should prove successful, as the production in this country of the calcium carbide required by the process is second only to that of Norway.

The monograph describes in detail the results obtained by the leading European chemists in their efforts to increase the supply of nitrogenous compounds, and the commercial as well as the technical aspects of the new industry are dealt with at length. The author, Thomas H. Norton, consul at Chemnitz, Germany, on detail as commercial agent of the Department of Commerce and Labor, states in conclusion that the achievements of applied chemistry make it possible for American industry and agriculture to face with confidence the threatened exhaustion of the nitrate deposits of Chile.

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Air Cushions for Automobiles

(Concluded from page 72.)

and the car body; that there is almost perfect balance in rounding curves; and that there is as nearly perfect working safety as can be secured. The machine has been undergoing severe tests for several months, having already run more than 4,300 miles over unfavorable roads, and is said to have given great satisfaction. Recently it has made a speed of forty miles per hour over an unusually rough road with great ease of movement.

RAILWAY WAGES AND COST OF LIVING IN THE UNITED STATES AND EUROPE

THE Bureau of Railway Economics has completed the second of its comparative studies of railway conditions in the United States and the principal countries of Europe. This relates to the wages paid railway employees and the cost of living, and is based on the latest years for which comparative data are available.

The average daily compensation of railway employees of all classes for the year 1910 was, in the United States, $2.23; in the United Kingdom, $1.05; excluding supplementary allowances negligibly affecting the average, it was in Prussia-Hesse 81 cents, and in Austria 89 cents. The lowest paid railway employee in the United States—the ordinary trackman—receives a greater compensation than many of the railway employees of France, even those of higher grades and with responsible duties. The compensation of railway employees is from two to three times as high in the United States as in Italy.

A recent report of the English Board of Trade on railway wages shows that the average weekly pay of enginemen in the United Kingdom in 1907 was $11.17; of firemen, $6.67. In the same year enginemen on American railways received an average weekly compensation of $25.80, counting six days to the week, and firemen $15.24. Recent returns make it clear that in 1912 enginemen and firemen in the United States are compensated at rates of pay for specific runs that are two, three and four times as high as the corresponding rates on representative English railways. The annual compensation of enginemen in the United States, as reported by two representative railway companies, now ranges from $1,100 in switching service to over $2,800 in passenger service, and of

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firemen from $700 in switching service to over $1,700 in passenger service.

For Continental Europe official returns in requisite detail are not available for a later year than 1908. The salaries and allowances of the typical engineman in Germany amounted for that year to $646.88, in Austria to $870.80; of a fireman in Germany to $424.59, in Austria to $532.03. The annual compensation of enginemen on two of the principal railways of France ranged in 1908 from $505.66 to $906.91, and of firemen from $324.24 to $595.98. In Italy enginemen received in 1908, salary and allowance included, from $581.10 to $812.70 a year; firemen, from $330.30 to $475.05 a year. In these Continental countries the maximum compensation is received only after many years of service.

The average annual compensation of enginemen in the United States in 1908, on an estimated basis of 300 days' service, was $1,335; of firemen, $792. In this country the rate of compensation to these employees does not depend on length of service.

In Belgium enginemen received in 1907 from $23.16 to $38.60 a month; firemen, from $17.37 to $23.16 a month; conductors and station employees, from 46 cents to 96 cents a day. In the United States, in the same year, 1907, enginemen averaged, on the basis of 25 days' service, $107.50 a month; firemen, $63.50 a month; conductors, $3.69 a day; station employees, from $1.78 to $2.05 a day.

The rental of a three or four-room house or flat is almost as high in Berlin, Paris or London as throughout the United States; but in England and on the Continent it generally runs from $30 to $90 a year less. The quantity of food and fuel estimated by the Board of Trade of England as the standard consumption of a typical workingman's family cost in the United States 17.8 per cent. more than in France or in Germany; 35.3 per cent. more than in Belgium, and 38 per cent. more than in the United Kingdom.

(Concluded on page 82.)

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Series Incandescent Street Lighting System

Bulletin No. 4952 takes up fully the General Electric series incandescent system of street lighting with its utilization of the series Mazda lamp and the constant-current transformer, which has accomplished such remarkable results by its economy and effectiveness in extending the benefits of street illumination to localities where efficient lighting otherwise, owing to the expense involved, would have been impossible. This system is of great service for small villages and outlying districts where street lighting appropriation is small, as well as for residential and suburban districts and narrow and crooked streets. It is also of special service for streets and roads where foliage is dense. The book contains much interesting data and many illustrations.

Pneumatic Drills

"Little David" Pneumatic Drills is the subject of a 16-page bulletin, form 8007, just issued by the Ingersoll-Rand Co., 11 Broadway, New York City. The tool, very simple in construction, is adapted in its various sizes for all the ordinary work of the pneumatic drill—drilling, reaming, tapping, flue rolling and wood boring. The motor or engine is of the angular, four-cylinder, single-acting, reciprocating type, each pair of pistons being attached to opposite throws of a double-crank shaft, and each acting in balance, insuring continuous smooth running. Machines are built reversible, but can be made non-reversing by simply inserting a small pin in hole provided in the throttle handle. The

valve action is such that there is no compression of exhaust, no matter which way the drill is running. There is no loss of speed and power. Catalogue is illustrated and shows machines in section and at work. A descriptive table gives the sizes and capacities.

Pneumatic Wood Carving Tools

A new departure, or, more strictly speaking, a new application of pneumatic tools, is shown and described in Bulletin No. 304, just issued by the Thomas H. Dallet Co., York and 23d streets, Philadelphia, Pa., who will promptly send a copy of the bulletin on request.

Power Transformers

In Bulletin 4953, entitled "Large Shell Type Transformers," and recently issued by the General Electric Company, the company endeavors to place before those interested some of the more important points regarding the relative merits of its different types of transformers.

The bulletin contains information intended to assist the prospective customer in determining the type of transformer best suited to his needs.

The bulletin supersedes the company's bulletin on this subject.

Hydro-Electric Power Development

The General Electric Company has just issued Bulletin No. 4966, devoted to hydro-electric power developments. Following a brief description, various important developments of this nature are given—some of them in considerable detail—and the bulletin contains numerous illustrations of both station and line construction. Among other developments described are the Great Western Power Company on the Feather River, north of Oakland, Cal.; Connecticut River Power Co., at Vernon, near Brattleboro, Vt.; Mississippi River Power Co., Keokuk, Ia.; Great Falls Water Power and Townsite Co., Great Falls, Montana; and Pennsylvania Water and Power Co., at McCall Ferry, on the Susquehanna River, in Pennsylvania.

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Stokers

Bulletin B-1, recently issued by the American Stoker Co., 11 Broadway, New York, is descriptive of their class "E" stoker, for whic hthey claim a distinct advance in design, by virtue of which it is capable of obtaining a greater efficiency than heretofore possible with other stokers.

This stoker is of the Underfeed type, so designed that the fuel is fed to the under side of the fire in such a manner as to effect the destructive distillation of the coal and the driving off of its volatile gases. These gases being liberated from the coal at the point in the retort, through which coal is fed, where the air is introduced for combustion. The volatile gases mix with the incoming air and the mixture passes through the incandescent coke above the retort, which results in the complete combustion of the gases.

The feeding and stoking mechanism of this stoker is such that a comparatively thin fire is maintained over the entire grate surface, which gives an intensely hot fire, complete combustion with a short flame and a correspondingly high furnace temperature, all of which make for high efficieney.

This bulletin, which contains many illustrations and much useful information, may be obtained by addressing the American Stoker Company, 11 Broadway, New York, and mentioning CASSIER'S MAGAZINE.

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The Ingersoll-Rand Company have issued a unique folder under the above title giving facts and points about their Imperial line of pneumatic hammers and drills, steam-driven air compressors, rock drills, air hoists, etc. A postal card to them at 11 Broadway, New York, will bring a copy.

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The Electrical Operation of Railroad Shops

"The Electrical Operation of Railroad Shops" is the title of Bulletin No. 4959, recently issued by the General Electric Company. The bulletin is profusely illustrated, shows the advantages of individual drive over group drive, and illustrates and describes electrical installations in some of the important railroad shops in the country.

The bulletin supersedes the company's previous bulletin on this subject.

Motor Drives

Bulletin No. 1139, issued by the Fort Wayne Electric Works, of Fort Wayne, Ind., is a handsome pamphlet containing many fine illustrations, and is devoted to showing some of the many applications of Fort Wayne motors.

Small Direct and Alternating Current Motors, Drawn Shell Type

Bulletin No. 4963, recently issued by the General Electric Company, describes a complete line of small motors ranging in size from 1/50 to ¼ horsepower, inclusive, wound for either direct or alternating current.

The distinguishing feature of these motors is the field construction, which consists of a steel shell or cylinder supporting and clamping together the stator or field punchings, thereby avoiding the use of the usual cast frame work outside the active magnetic material. These motors are unusually compact, and are especially designed for application to various small machines which may be driven by electric power. They are conservatively rated, not on an input basis, but on the actual brake horse-power developed at the pulley, and, in addition to their normal rated capacity, have ample reserve to withstand a reasonable percentage of overload.

The illustrations show the completed motors, and also show the various manufacturing processes and structural details. There are, in addition, a number of typical motor applications shown.

Electric Power in the Lumber Industry

Bulletin 4962, recently issued by the General Electric Company, is devoted to the use of electric power in the lumber and woodworking industries. The bulletin contains illustrations of installations of motors used in connection with various branches of the industry, discusses alternating current vs. direct current in this connection, and contains descriptions of several important electrical installations of this nature.

Personal

Miss Remington has written an exceedingly comprehensive, yet condensed, description of the Remington-Wahl Adding and Subtracting Typewriter, published with many illustrations by the Remington Typewriter Company.

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Railway Wages and Cost of Living

(Concluded from page 75.)

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This book, however, which is issued by the J. G. White & Company, Inc., the builders of the plant for the Eastern Tennessee Power Co., takes up this development in greater detail, and contains a number of very handsome color illustrations.

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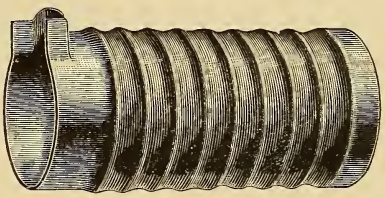

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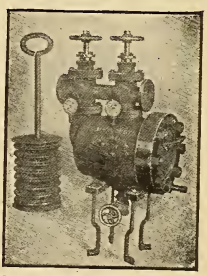

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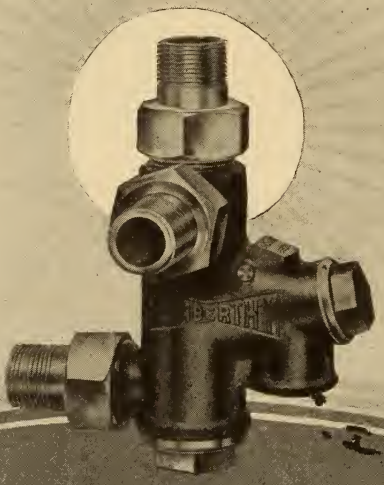

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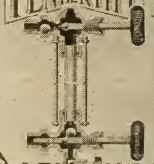

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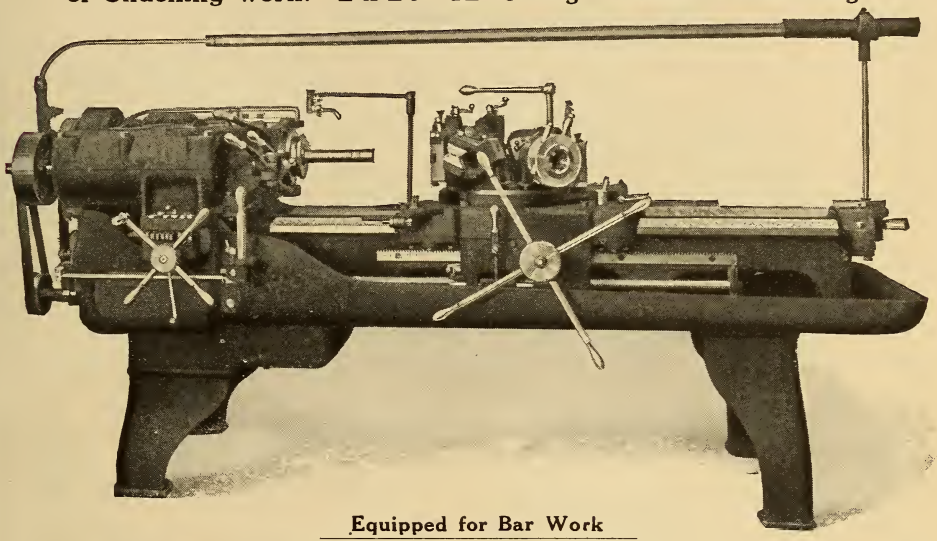

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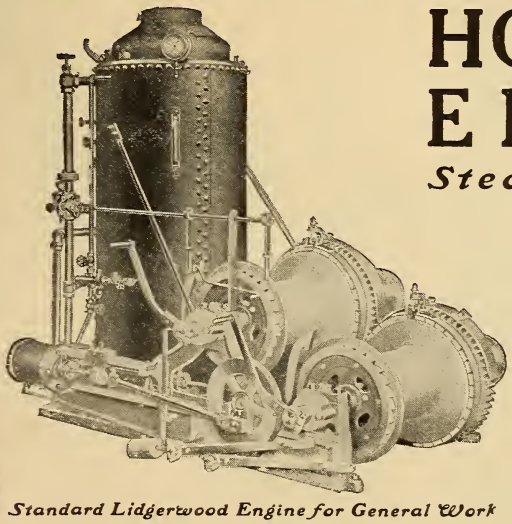

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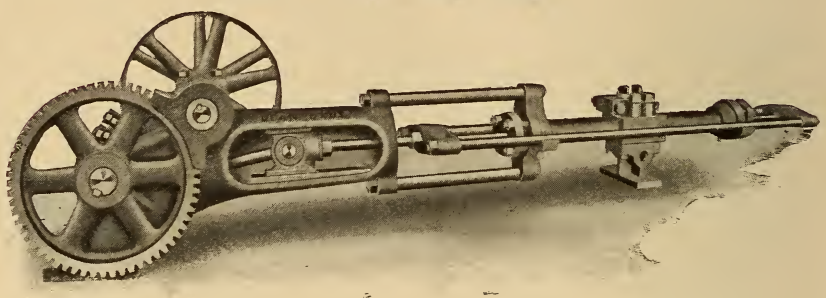

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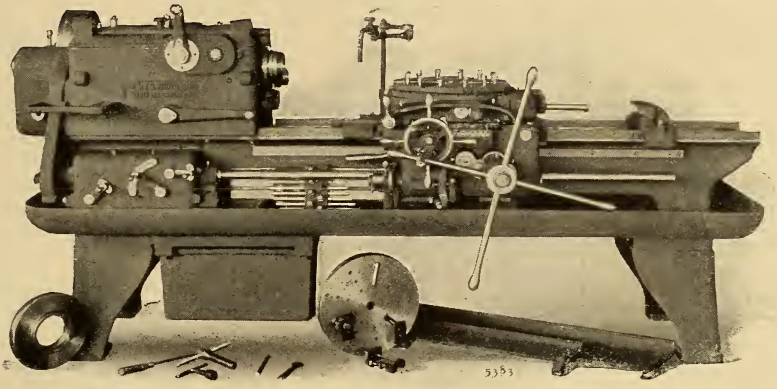

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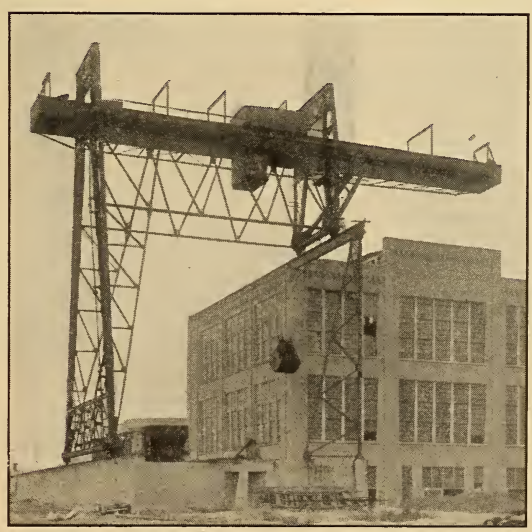

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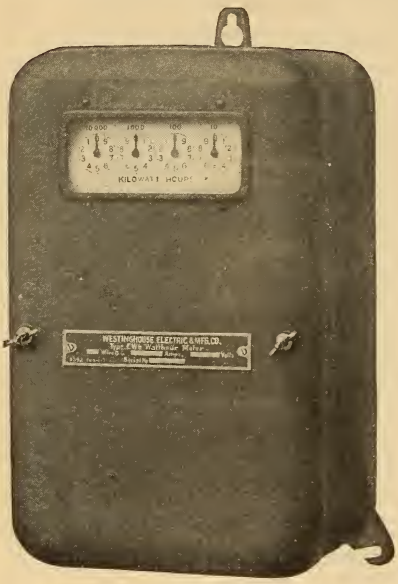

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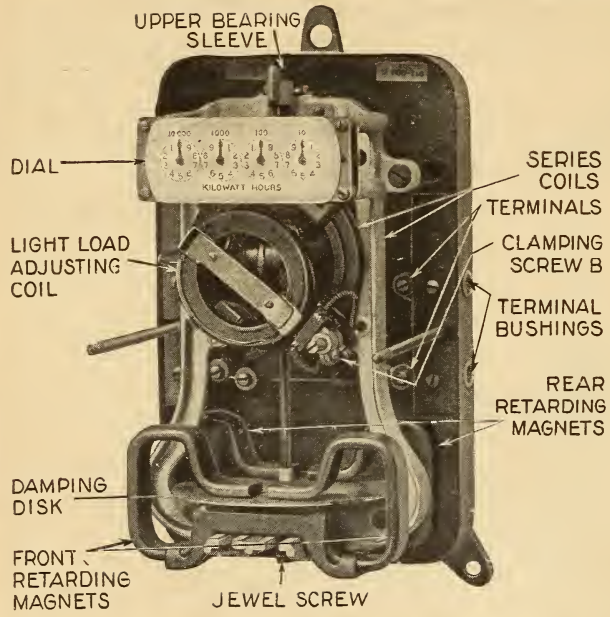

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